SURPRISE
ARIZONA

FINAL Report

Integrated Water Master Plan
Water Infrastructure

JULY 2009

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4957-002

MALCOLM PIRNIE

City of Surprise, Arizona

Public Works Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Water Infrastructure

July 2009

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A. System Performance and Design Criteria

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Table A-1. Comparison of Drinking Water Infrastructure Design Criteria

City		City of Phoenix	City of Peoria	Arizona American Water	City of Goodyear	AWWA Distribution System Handbook	AWWA Manuals	City of Surprise Current	City of Surprise Recommended
Peaking Factors	**Max Day Demand/Average Day Demand**	2	1.6	1.8	1.7	1.5-3.5	-	2	2
	Peak Hour Demand/Average Day Demand	3.4	3.2	3	2.89	2.0-7.0	-	3	3
Wells/Production Facility	**Production Capacity**	1.1 X Maximum Day	1.1 X Maximum Day	Maximum Day Demand	Maximum Day Demand	Maximum Day Demand	-	1.25 X Maximum Day Demand	Maximum Day Demand
	Firm Capacity	-	-	Must meet the max day demand for an entire booster station with one well out of service	-	Must meet maximum day demand with largest well out of service	-	-	Must meet maximum day demand with largest well out of service.
Arsenic Treatment	**Treatment Capacity**	-	-	-	-	-	-	Average Day Demand	Maximum Day Demand
Storage Facility	**Equalizing Storage**	Minimum of 20% of max day flow	20 % of maximum day demand	30 % of maximum day demand	EQ = (Peak Hour Demand – Max Day Demand) x 6 hours	25 % of max day demand	10-15 % of the average demand	1.2 X Avg Day Demand	20 % of Max Day Demand
	Fire Storage	Fire Flow X Duration	$G = 1{,}020\ (P)^{1/2}\ (1 - 0.01\ P^{1/2})$*	Fire Flow X Duration	Fire Flow X Duration	Fire Flow X Duration	Flow Duration X Fire Flow (M 31)		Fire Flow X Duration
	Emergency Storage	10% of max day flow	10 % of maximum day demand.	10 % of maximum day demand	Larger of 2 X EQ or EQ + Fire Flow	Dependent on the owner	Refer M19		10 % of Max Day Demand
Pipe Sizing – **Distribution (WSF to End User)**	**Velocity**	< 5 ft/s	≤ 5 ft/s for pipes < 36 inches diameter	less than 10 ft/s	< 10 ft/s	-	< 5 ft/s	< 5 ft/s	< 5 ft/s
	Headloss	< 10 ft/1,000 ft	2 to 7 ft/1,000 ft	< 10 ft/1,000 ft	2-3 ft/1,000 ft	-	< 6 ft/1,000 ft	<10 ft/ 1,000 ft	<10 ft/ 1,000 ft
	Design Criteria	Max Day+ Fire Flow	Larger of the Maximum day demand plus fire flow, or Peak hour demand.	-	Peak hour	-	Max Day + Fire Flow	Max Day + Fire Flow	Larger of peak hour demand or maximum day plus fire flow
Fire Flow Condition	**Velocity (during Max Day + Fire Flow)**	< 10 ft/s	<10 ft/s	-	-	-	-	-	
Transmission (Wells to WSF)	**Velocity**	< 5 ft/s	≤ 6 ft/s for pipes ≥ 36 inches diameter	> 2 ft/s and < 6 ft/sec	< 10 ft/s	-	< 5 ft/s	-	<5 ft/s
	Headloss	<6 ft/1,000 ft	1 to 2.5 ft/1,000 ft	< 10 ft/1,000 ft	2-3 ft/1,000 ft	-	< 2 ft/1,000 ft	<10 ft/ 1,000 ft	< 2 ft / 1,000 ft
	Design Criteria	Max Day+ Fire Flow	Larger of the Maximum day demand plus fire flow, or Peak hour demand.		Peak Hour	-	Peak hour or Max storage replenishment rate	Max Day + Fire Flow	Max Day
Fire Flow	**Single Family Residential**	1,000 gpm	1,000-1,500 gpm for 2 hrs	1,500 gpm for 2 hours	1,000 gpm X 3 hours	500 - 2,000 gpm	-	2,000 gpm for 2 hours	2,000 gpm for 2 hours
	Multi Family Residential	1,500 gpm	1,500-2,500 gpm for 2 hrs			1,500-3,000 gpm	-	2,000 gpm for 2 hours	2,000 gpm for 2 hours
	Commercial	3,000 gpm	3,000-8,000 gpm for 3 -4 hours	3,000 gpm for 3 hours (minimum)	3,500 gpm X 4 hours	2,500-5,000 gpm	-	3,000 gpm for 3 hours	3,000 gpm for 3 hours
	Industrial	5,000 gpm	4,000-10,000 gpm for 4 hours			3,500-10,000 gpm	-	3,000 gpm for 3 hours	3,000 gpm for 3 hours
System Pressure	**Maximum Pressure**	100 psi	100 psi at peak hour demand	90 psi	100 psi	65-75 psi service	-	80 psi	100 psi
	Max Day/Peak Hour Conditions	Between 50 psi and 100 psi	Between 50 and 100 psi with minimum 40 psi service pressure	40 psi minimum (for maximum day)	50 psi minimum	25-35 psi minimum	-	40 to 80 psi	40 psi to 100 psi
	Fire Flow Conditions	25 psi minimum	20 psi minimum at max day + fire flow	20 psi minimum at max day + fire flow	20 psi minimum	20 psi minimum	-	20 psi minimum	20 psi minimum
Booster Station	**With Storage**	Design for Max Day	Maximum day Demand, plus 10%	Larger of peak hour demand or maximum day plus fire flow	Peak Hour	-	Constant Speed Pumps, Must meet all extreme and average flow conditons	-	Larger of peak hour demand or maximum day plus fire flow
	Without Storage	Design for Peak Hour for Max day + Fire Flow	Larger of peak hour demand or maximum day plus fire flow, plus 10%			-	Variable Speed Pumps, Must meet all extreme and average flow conditons	-	
	FIRM Capacity	Largest Pump out-of-service	Largest Pump out-of-service	Largest Pump out-of-service	Largest Pump out-of-service	-	Largest Pump out-of-service	-	Largest Pump out of service

Note:*G = fire demand rate, gal/min; P = population in thousands

Table A-2. Comparison of Wastewater Collection System Design Criteria

City			City of Phoenix	City of Peoria	Arizona American Water	City of Goodyear	City of Surprise (Current)	City of Surprise (Recommended)
Peaking Factor	**Peak Flow**	**Dry Weather**	$1 + 14/(4+ P^{1/2})$	$1 + 14/(4+ P^{1/2})$	3 (Peak Hour)	-	< 12-inch = 4 ≥ 12-inch = 2.5	< 12 inch = 4 ≥ 12 inch = 3
		Wet Weather	-	1.17 -1.3	-	-		
Collection System Pipes	**Gravity**	**Design Criteria**	Peak Flow	-	-	-	-	Peak Flow
		Manning's Coefficient	0.013	0.013	0.013	-	0.013	0.013
		Minimum Velocity	2.1 ft/s to 3.4 ft/s for 8 inch to 120 inch diameter pipes	2 ft/s when the pipe is flowing half full	2 ft/s at peak hour and in trunklines at average daily flow	2.5 ft/s	2 ft/s when flowing full	2 ft/s when flowing full
		Maximum Velocity	9 ft/s when flowing full	8 ft/s	10 ft/s	10 ft/s	9 ft/s	9 ft/s
		Minimum Pipe Size	8 inch	8 inch	8 inch	-	8 inch	8 inch
	Force Main	**Design Criteria**	Peak Flow	normal operating velocities between 3 and 7 ft/s to provide scour velocity	-	Max Velocity - 6 ft/s Minimum Velocity - 2.5 ft/s	-	Max Velocity - 8 ft/s Minimum Velocity - 3 ft/s
Depth Ratio	**Peak Dry Weather**	**Future pipes**	< 0.8 for peak hour	0.8 during peak hour flows for >= 12 inches, 0.5 for smaller diameters	0.75 maximum for peak hour	0.6	-	0.8
		Existing pipes		0.9 at peak hour flows			-	
	Peak Wet Weather	**Future pipes**		0.9 for 12 inches and higher		0.65	-	
		Existing pipes		< 1			-	
Lift Stations	**Firm Capacity**		-	Largest pump out of service	-	-	-	Largest pump out of service
	Design Criteria		-	Peak Day Flow	-	-	-	Firm Capacity Exceeds Peak Flow

Note: P = Population/1000

Table A-3. Comparison of Reclaimed Water Infrastructure Design Criteria

Design Parameters			Tucson Water, Tucson, AZ	City of Raleigh, NC	City of Goodyear, AZ	City of Surprise, AZ (Current)	City of Surprise, AZ (Recommended)
Peaking Factors		Maximum Day Demand/ Average Day Demand	2.64	-	1.7	2	2
		Peak Hour Demand/ Average Day Demand	7.9	-	4.1	6	5
Storage Facility			Maximum Day Demand	-	1.5-2.0 x Equalization Volume	Average Day Demand	Average Day Demand
Pipe Sizing	Distribution	Velocity	< 5 ft/s	-	< 5 ft/s	< 5 ft/s	< 5 ft/s
		Headloss	<10 ft/ 1,000 ft	<5 ft/ 1,000 ft	-	<10 ft/ 1,000 ft	<10 ft/ 1,000 ft
		Design Criteria	-	Peak hour of maximum day	Peak hour of maximum day	Peak hour of maximum day	Peak hour Demand
	Transmission	Velocity	-	-	< 5 ft/s	-	< 5 ft/s
		Headloss	-	-	-	-	<10 ft/ 1,000 ft
		Design Criteria	-	-	-	-	Access Reclaimed Water Available
	Recharge Mains	Velocity	-	-	< 5 ft/s	-	< 5 ft/s
		Headloss	-	-	-	-	<10 ft/ 1,000 ft
		Design Criteria	-	-	-	Maximum Recharge Demand	Maximum Reclaimed Water Available
System Pressure		Maximum Pressure	75 psi	Same as potable system	65 psi	100 psi	100 psi
		Minimum Pressure (Peak Hour Conditions)	-	25 psi	22 psi		25 psi
Booster Station Design Criteria		at WSF	Maximum Day	-	-	Peak Hour	Peak Hour
		at Distribution System	-	-	Peak Hour		
		at WRF	-	-	-	-	Maximum Recharge
		at Transmission Mains Boosting to WSF only	-	-	-	-	Maximum Day Demand

Table A-4. Comparison of Spreading Basin Design Criteria

Parameter	Crites et al., 2000[1]	Hieroglyphics Recharge Facility	El Mirage Recharge Basins	Assumed Standard
Loading Rate (ft/year)	200	730[2]	1,241	122
Loading Rate: Infiltration Rate (%)	27	--	--	33
Infiltration Rate (ft/day)	2	2	4	1
Wet/Dry Ratio	0.75	>8.0[2]	1.0	0.5
Application Period (days)	1-3	Nearly continuous	4	4
Drying Period (days)	4-10	0	4	8
Number of Basins (#)	4-5	7	3	3
Basin Depth (ft)	Minimum 1 ft freeboard	>6	5	5
Sidewall Slope (Rise:Run)	1:2 to 1:3	--	1:3	1:3
Ramp Gradient (%)	10-20	--	10	10
Distance Between Basins (ft)	10-12	--	8	12

NOTES:

(1) As cited in the USEPA Process Design Manual: Land Treatment of Municipal Wastewater Effluents (September 2006).

(2) A constant wet/dry ratio was not applied. Instead, basins were dried when the infiltration rate decreased. In some cases, wet application periods were greater than six weeks.

B. Drinking Water System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 4.3 – Fire Flow Testing
- Task 4.4 – Flow Model

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Integrated Water Master Plan

Water Infrastructure Technical Memorandum:

Task 4.3 -- Fire Flow Testing
Task 4.4 – Flow Model

November 2008

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4957-005

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Appendices

A. Fire Flow Test Results

1. Introduction

1.1. Background

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also

includes updates to projections of wastewater flows, reclaimed water availability, and reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

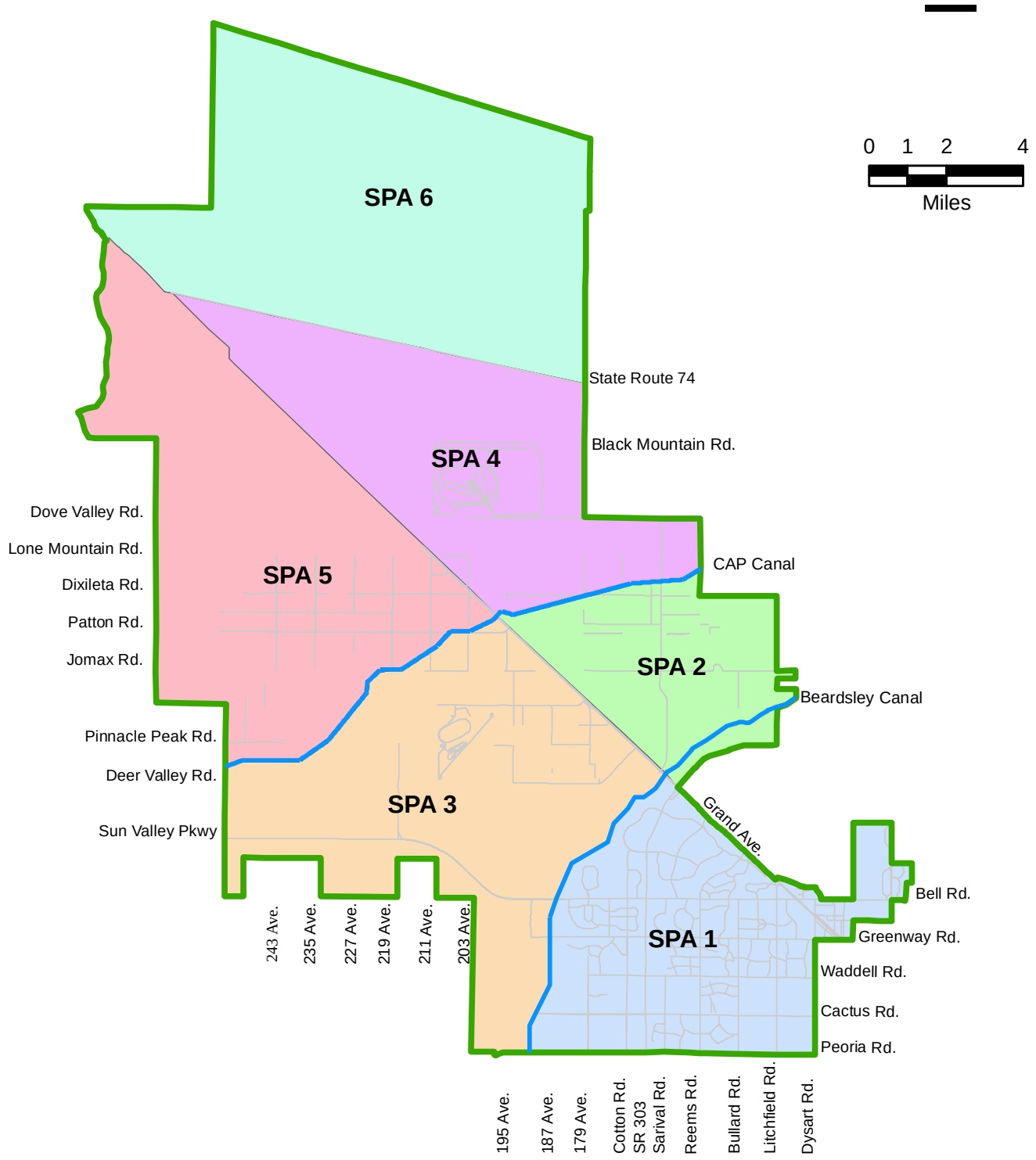
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
Recharge Master Plan	5.7 Wastewater Master Plan Report
3.1 Regulations and Background Information	**Reclaimed Water Master Plan**
3.2 Recharge Methods and Evaluation	6.1 Review of Background Information
3.3 Recharge Improvements	6.2 Flow Model
3.4 Build-out of the Recharge System	6.3 Evaluation of the Existing System
3.5 Recharge Master Plan Report	6.4 Improvements to the Existing System
	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Water Infrastructure Master Plan Tasks 4.3 (Fire Flow Testing) and 4.4 (Flow Model). The technical memorandum includes descriptions of how the water infrastructure flow model was developed, the hydrant flow testing that was conducted, and the process used to calibrate the flow model using the hydrant test results. In future tasks, the calibrated model will be used to evaluate the existing system and future scenarios to determine necessary water infrastructure improvements.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's municipal planning area (MPA). The MPA has been divided into six SPAs for convenience of reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Streets
- Canals
- Municipal Planning Area
- Special Planning Areas

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Study Area

November 2008 | **Figure 1-1**

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2. Model Development

The City's water distribution system was modeled using personal computer based modeling software and related databases. The modeled system served as a tool to aid in determining the adequacy of the existing system to support varying supply and demand conditions and to identify water system modifications and expansions necessary to meet future demand. This section describes the development of the City's existing drinking water distribution system model.

2.1. Data Sources

The primary sources of information for the current modeling effort were the most current geographical information system (GIS) shapefiles provided by the City and the hydraulic model that was created for the City's previous Water Infrastructure Master Plan. Supplemental information for the model was collected during field visits conducted in May 2008 and through interviews with City staff. Water demands were obtained from the Water Resource Demand Module (Demand Module) developed previously as a part of Water Resources Master Plan Tasks 2.5 (Demand Factors) and 2.6 (Demand Module).

2.2. Generic Model Description

The City's water distribution system pipelines, storage tanks, boosters, and valves were modeled using Bentley WaterCAD® V8 XM edition. The software uses an iterative procedure to determine the steady state system response to a given supply and demand scenario. The software is also capable of performing extended period simulations for known diurnal patterns of supply and demand and can simulate water quality fluctuations within the distribution systems. A steady state model was developed for the current master planning effort. The results obtained from such quantitative analyses are considered conservative for evaluating the existing system and planning for future improvements and system developments.

2.2.1. Transmission Pipelines

The City's existing potable water distribution transmission system consists of polyvinyl chloride (PVC) and ductile iron (DI) pipes, ranging in diameter from 1 inch through 30 inches. Most pipelines in the system followed existing streets and public rights-of-way.

The City's existing potable water distribution system was represented by more than 7,500 pipes in the GIS database. A skeletonized network of pipes was represented in the existing water system model provided. Skeletonization is typically performed using

standard modeling procedures to remove pipes that do not change or affect the hydraulics of the system. All of the major transmission lines, 10-inch or greater, were represented in the existing model. Table 2-1 provides the statistics on percentage of pipes represented in the model. A map of the modeled pipes is shown on Figure 2-1 and Figure 2-2 for SPA 1 and SPA 2, respectively. In total, the pipes in the model accounted for 49 percent of the total pipe length and 70 percent of the total water volume in the distribution system.

Table 2-1.
Summary of Modeled Pipes

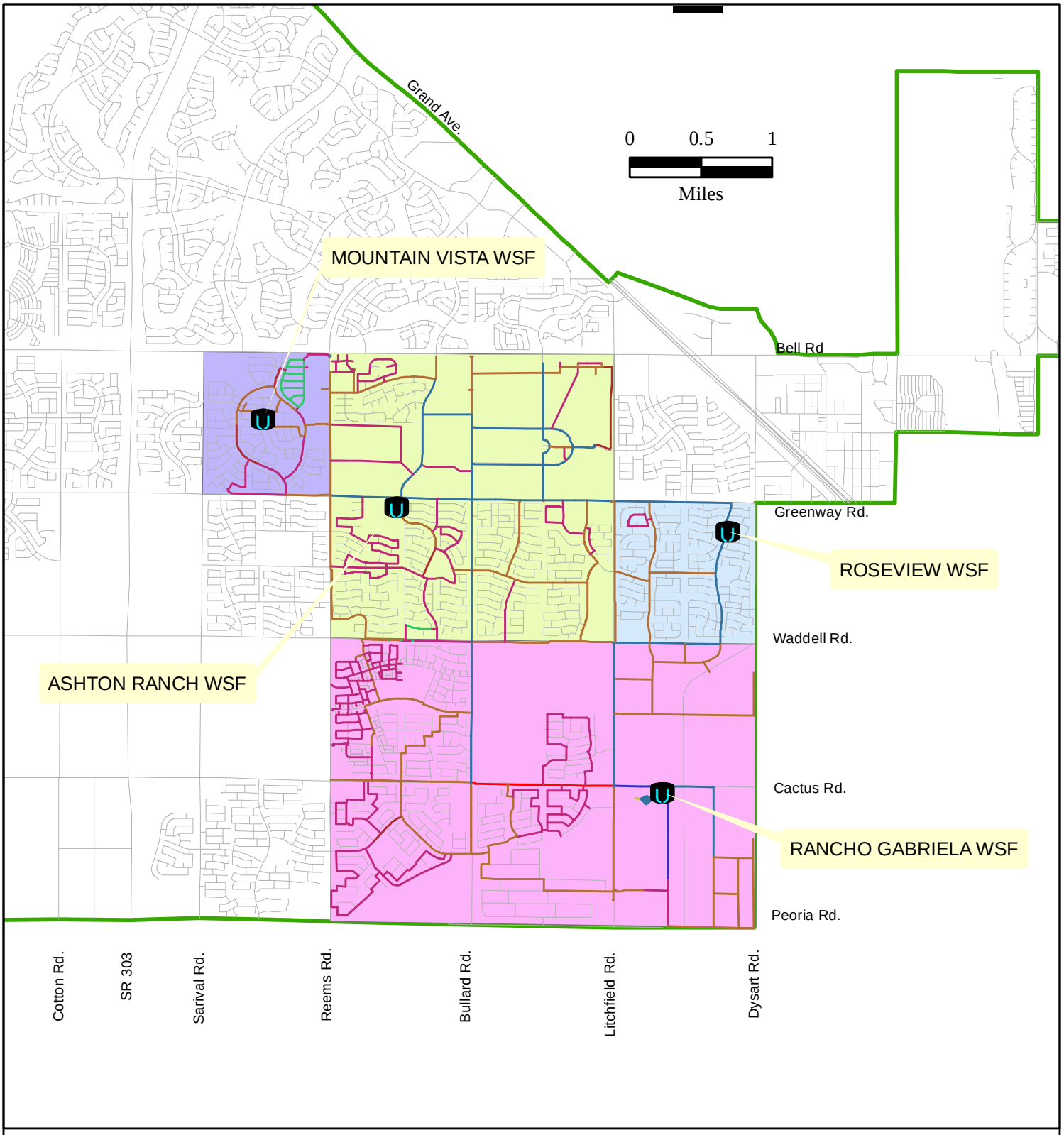
Pipe Diameter (in)	Length (feet)			Volume (gallons)		
	Total	In Model	% in Model	Total	In Model	% in Model
1	133	0	0	5	0	0
2	748	0	0	122	0	0
3	1,648	0	0	605	0	0
4	7,557	0	0	4,933	0	0
6	93,019	23,291	25	136,617	34,207	25
8	621,290	177,187	29	1,622,195	462,637	29
10	11,839	11,839	100	48,298	48,300	100
12	166,538*	166,568	100	978,374	978,550	100
16	115,555	115,555	100	1,206,862	1,206,857	100
20	5,515	5,515	100	89,998	89,998	100
24	5,618	5,618	100	132,018	132,018	100
Total	1,029,459	505,573	49	4,220,028	2,952,568	70

Note: *Some pipes with incorrect diameters in the City's GIS were corrected in the model based on information provided by the City

2.2.2. Model Nodes

Model nodes can serve a number of functions and contain vital information concerning supply, demand, and physical characteristics of certain facilities. Two types of nodes were used in the modeled distribution system: boundary nodes and junction nodes.

Tanks and reservoirs were classified as boundary nodes. The storage facilities in the system were represented as cylindrical tanks with a known diameter and height. The base elevations of the tanks were verified with the City. The initial tank level represented the known hydraulic grade line (HGL) in the model. Junction nodes occur at all pipeline endpoints that were not represented by a tank or reservoir. Each junction has specific information that identified the node's elevation, demand, and demand type. Each node in the model was assigned an elevation that corresponds to the local surface elevation relative to the mean sea level, based on the most recent United States Geological Survey (USGS) five-foot interval topographical data.



Legend

Streets

Water Supply Facility

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

- Mountain Vista Ranch
- Ashton Ranch
- Rancho Gabriela
- Roseview

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

SPA 1 Modeled Water Distribution System (Skeletonized)

November 2008

Figure 2-1

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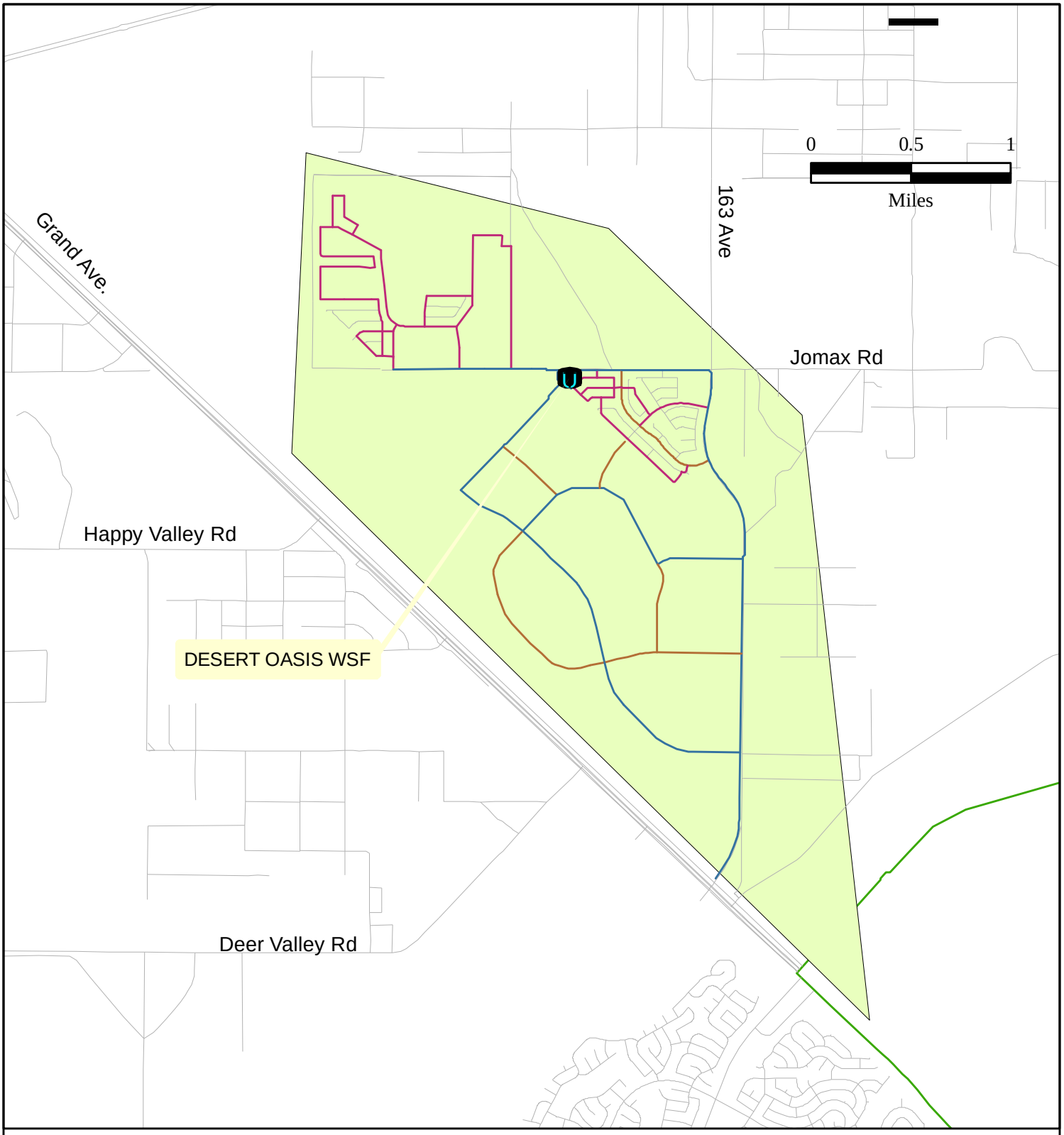

Legend

Streets

Water Supply Facility

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

Desert Oasis

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INTEGRATED WATER MASTER PLAN

SPA 2 Modeled Water Distribution System (Skeletonized)

November 2008

Figure 2-2

M:\4957005\GIS\Project_MXDs\Tech Memo 2\Figure 2_2_SPA2_Modeled Distribution System Pipes.mxd

2.2.3. Pumps

Each pump in the system was modeled using a single design point pump curve. The point represented the designed flow and head for the pump. The design point information for each pump was noted from the manufacturer's tag on the pumps during the field visit and was verified by City Staff. The elevation of the pump was assumed to be the same as the base elevation of the tank.

2.2.4. Valves

The City has pressure reducing valves (PRVs) at various locations within the distribution system. PRVs were used in the distribution system to prevent the downstream hydraulic grade from exceeding a preset value. The elevation, diameter, and existing pressure setting value for each PRV were verified with City staff.

2.2.5. Water Demand Allocation

The total existing (2007) water demand included demands for indoor use (e.g., plumbing fixtures), outdoor use (e.g., residential and commercial outdoor irrigation), and landscape use (e.g., large turf and xeriscape areas such as parks and schools). In 2007, the annual average demand for the existing City water service area (i.e., not including Arizona American Water Company and El Mirage) was 6.97 mgd, based on customer billing data. The nearest-node demand allocation method was used to allocate the demand to the modeled junctions. This method used the spatial analysis capabilities of GIS to assign the water usage demand polygons from the Demand Module to the nearest demand node.

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3. Model Calibration

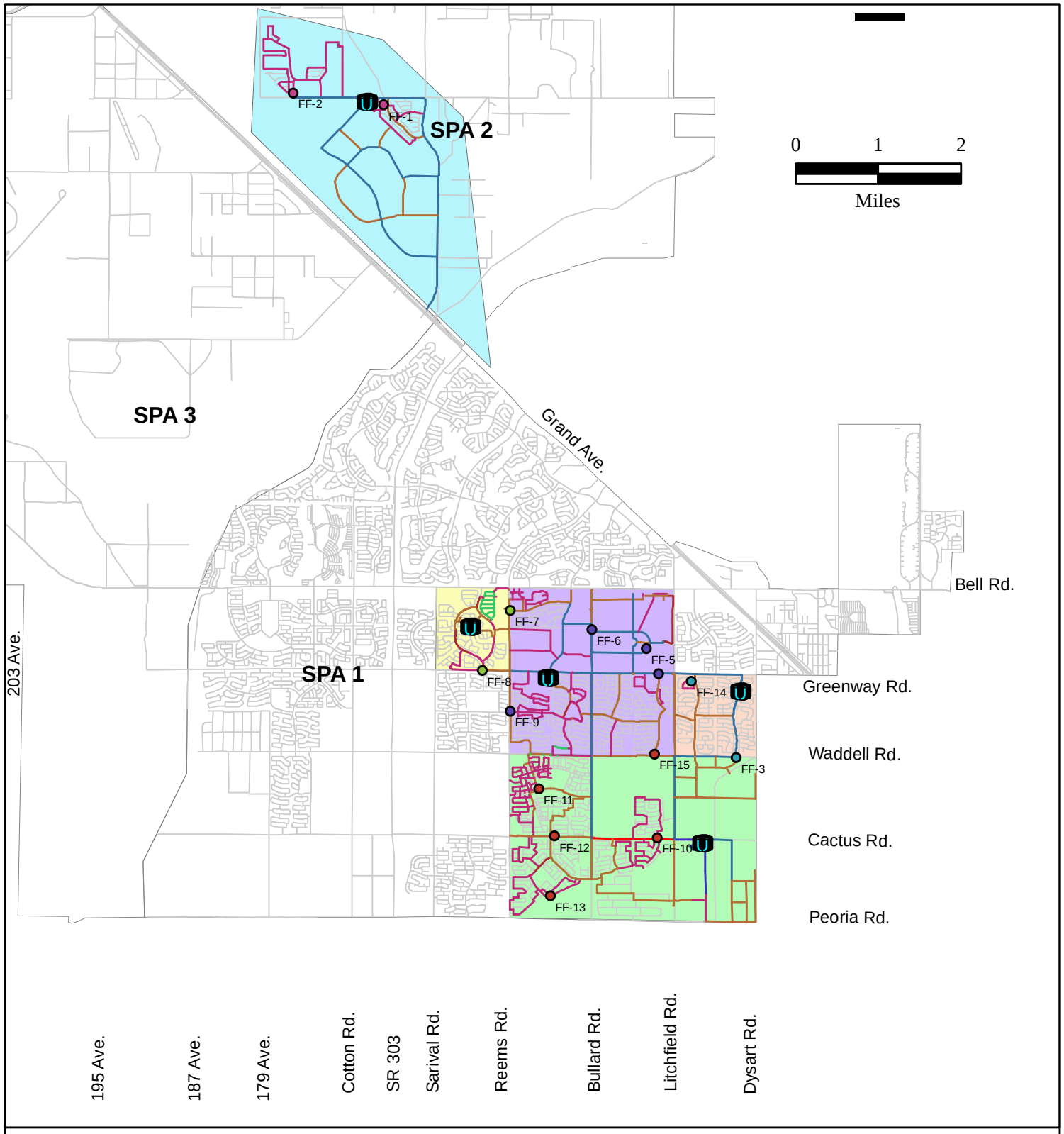
This section describes how the City's existing water system model was calibrated. Model calibration was necessary before conducting a system analysis to ensure that the model setup represents the actual system with sufficient accuracy. The level of calibration depends on the intended use of the model. The model developed for this project was a steady-state model with primary use as a master planning tool. Flow and pressure information gathered from fire hydrant tests performed throughout the system were used to calibrate the model.

3.1. Fire Flow Testing

Fire flow tests were conducted to determine the pressure and flow at several locations within the distribution system. The primary objectives of fire flow testing are to determine the general condition of the distribution system and to determine how much water is available for fighting fires. These tests simulate high flow conditions, thereby allowing the system to be analyzed under extreme conditions. The results from fire hydrant tests can be used to calibrate a hydraulic model as they provide pressure data during static and stressed conditions.

A typical fire flow test involves two or more hydrants: a residual hydrant where the residual pressure is measured and one or more flow hydrants, selected downstream of the residual hydrant. The first step of the process is to read the static pressure at the chosen residual hydrant. A flow hydrant near the residual hydrant is then opened and allowed to flow. Once the flow stabilizes, simultaneous readings for pressure at the residual hydrant and flow at the flow hydrant are taken. Thus, each test provides a static water pressure reading, a residual water pressure reading, and a pitot reading to determine the flow available through a hydrant.

Fifteen hydrants were chosen for fire flow tests based on the information from the existing model, GIS-based water infrastructure, and consultation with the City. The fire flow locations are shown on Figure 3-1 and summarized in Table 3-1. The location and number of hydrants chosen depended on the size of the water supply facility (WSF) service area and on the characteristics that needed to be captured in the test. The Rancho Gabriela WSF had the largest service area, hence five fire flow test locations were chosen for this system. The Ashton Ranch WSF had the next biggest service area, and four test locations were selected in that system. The other WSF systems had two locations each. The test hydrant locations within each service area were selected based on flow direction



Legend

Streets

Water Supply Facility

Fire Flow Locations

- Ashton Ranch
- Desert Oasis
- Mountain Vista
- Rancho Gabriela
- Roseview

Pipe Diameter (inch)

- 6
- 8
- 10
- 12
- 16
- 20
- 24
- 30

WSF Service Area

- Mountain Vista Ranch
- Ashton Ranch
- Desert Oasis
- Rancho Gabriela
- Roseview

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CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Fire Flow Locations

November 2008

Figure 3-1

M:\4957005\GIS\Project_MXDs\Tech Memo 2\Figure 3_1_FireFlow Locations.mxd

and proximity of the hydrant to high demand areas such as dense residential areas or major commercial areas.

Table 3-1.
Fire Flow Locations

Location ID	Location	Hydrant ID	Service Area
FF-1	N 167th Av and W Tether Trail	WTFH4N2WNW010021	Desert Oasis
FF-2	W Spur Dr and N 175 Lane	WTFH5N2WSW350016	Desert Oasis
FF-3	133rd and Waddell/Thunderbird	WTFH3N1WNE150006	Roseview
FF-4	140th and Greenway Rd	WTFH3N1WNE090013	Ashton Ranch
FF-5	142nd by Court House	WTFH3N1WSE040009	Ashton Ranch
FF-6	Bullard and 1/2 mile north of Greenway	WTFH3N1WNW040003	Ashton Ranch
FF-7	Reems Rd and 2 Blocks South of Bell Rd	WTFH3N1WNW050002	Mountain Vista
FF-8	Greenway Rd and Mountain Vista Ranch Rd	WTFH3N1WNE070040	Mountain Vista
FF-9	Reems Rd and 1/2 mile south of Greenway	WTFH3N1WNW080043	Ashton Ranch
FF-10	140th Ave and Cactus Rd	WTFH3N1WSE160011	Rancho Gabriela
FF-11	NE Corner of W Sweetwater Av and N Founder Park Blvd	WTFH3N1WNW170013	Rancho Gabriela
FF-12	W Cactus and 2 Blocks East of N 151st Ave	WTFH3N1WSE170006	Rancho Gabriela
FF-13	W Gabriela Dr, South of N 151 LN and W Becker Rd	WTFH3N1WSE200002	Rancho Gabriela
FF-14	NW Corner of W Acapulco Lane and N 137th Lane	WTFH3N1WNW100020	Roseview
FF-15	Waddell Rd and 140th Ave, North East Corner	WTFH3N1WSE090052	Rancho Gabriela

The fire flow tests were conducted on two days during the second week of June 2008. Areas with high construction activities were tested on Sunday to minimize the effect of construction water on the flow testing. The fire flow testing followed the schedule below:

- Day 1: Sunday June 8th – Location IDs FF- 1, 2, 4, 5, 6, 7, and 8
- Day 2: Monday June 9th – Location IDs FF- 3, 9, 10, 11, 12, 13, 14, and 15

3.2. Fire Flow Test Results

The fire flow tests were conducted three times throughout the day at each location to capture the variation in available flow during these times. Table 3-2 shows the average of the three fire flow tests results at each location. The results for the individual tests are presented in Appendix A.

Table 3-2.
Summary of Fire Flow Test Results

Fire Flow Location	Residual Hydrant		Flow Hydrant	
	Static Pressure (psi)	Residual Pressure (psi)	Flow (gpm)	Max Flow @ 20 psi residual pressure (gpm)
FF-1	75	67	1,237	3,317
FF-2	99	87	1,417	3,819
FF-3	85	70	1,310	3,115
FF-4	76	61	1,213	2,451
FF-5	81	71	1,272	3,389
FF-6	77	69	1,150	3,332
FF-7	61	55	1,134	3,042
FF-8	83	73	1,339	3,721
FF-9	80	69	1,303	3,204
FF-10	88	76	1,360	3,509
FF-11	72	60	1,209	2,725
FF-12	80	66	1,170	2,690
FF-13	85	70	1,288	2,917
FF-14	74	56	1,166	2,133
FF-15	94	75	1,376	2,902

3.3. Model Calibration

The City's water distribution system model was calibrated using the fire flow test results described in the previous section. The model was assumed to be calibrated for master planning purposes if the pressure predicted by the model was within ±10 percent of pressure measured at the calibration data points, or fire flow locations. In the event that these ranges were not achieved, possible explanations were explored for correction. However, it is typically not imperative to meet all calibration guidelines in order to have a fully calibrated model.

The following steps were used in calibrating the City's water distribution system hydraulic model:

- Allocate demands to the nodes
- Adjust the status and operating conditions of the modeled system facilities to reflect their status during the fire flow testing
- Adjust the network parameters to calibrate the model

3.3.1. Demand Allocation

The load builder wizard in WaterCAD® was used to allocate the base demands to nodes in the City's hydraulic model using the nearest node method. This demand allocation method assigns demands to the closest junction. The input to the load builder wizard was the demands developed by the Demand Module. The "existing demands" in the Demand Module were based on customer billing data and historical production data. Thus, the base demand allocated to the model nodes portrays the current demand in City's distribution system.

After assigning the base demand to the model nodes, fire flow demands were individually applied to the appropriate nodes as a single fixed demand. A new demand alternative was created in the model for each fire flow test.

3.3.2. Adjustment of Facilities Status

Operation data from the each WSF were collected before, during, and after the fire flow tests. The information included the tank water levels, number of operating pumps, the discharge pressure at the WSF, and flow from the WSF. The modeled system facilities were modified to reflect their status during the time period when the fire flow tests were conducted. Specific modifications included the open/closed status of the pipes, operating status of the pumps, and discharge pressure setting in the PRVs.

In general, all modeled pipelines within the distribution system were assumed to be open, except for the pipes connecting the different WSF service areas. These connecting pipes were assumed to be closed such that each WSF service area could be isolated and modeled as an independent distribution system.

3.3.3. Adjustment of Network Parameters

Network parameters such as pipe roughness and valve settings can be adjusted to make the model predictions in close accordance to the field observations. Pipeline roughness coefficients (C- factors) were adjusted globally to improve the correlation of the measured data to the model output. C-factors of 120 for DI pipes and 140 for PVC pipes were initially assumed. The calibration results showed that further adjustments to the C-factors were not necessary.

One PRV in the Desert Oasis system was currently modeled. The modeled set point for this PRV was adjusted to match the pressures measured during the fire flow tests in that WSF service area.

3.3.4. Calibration Results

A comparison of modeled and measured fire flow data are presented in Table 3-3. Modeled system pressures during fire flow tests were, on average, within 10 percent of the field measured values, and modeled flows at WSFs were, on average, within 13 percent of the field measured values. The exact elevation of the pressure gauges at the hydrants was not noted in the field and was assumed to be 5 to 10 feet above the pipeline. This might have introduced a difference between the measured and modeled pressures.

Table 3-3.
Calibration Comparison for the Node Pressures

Location	WSF	Residual Pressure				
		Measured (psi)	Modeled (psi)	Difference (psi)	Percent Difference	Calibration Goal Met?
FF-1	Desert Oasis	66	60	6	9	Yes
FF-2	Desert Oasis	87	89	2	3	Yes
FF-3	Rancho Gabriella	70	67	3	5	Yes
FF-4	Ashton Ranch	61	87	26	43	No
FF-5	Ashton Ranch	71	80	9	13	Yes
FF-6	Ashton Ranch	69	75	6	9	Yes
FF-7	Ashton Ranch	55	61	7	12	Yes
FF-8	Mountain Vista	73	61	13	17	No
FF-9	Ashton Ranch	69	71	3	4	Yes
FF-10	Rancho Gabriella	76	78	2	2	Yes
FF-11	Rancho Gabriella	58	59	0	1	Yes
FF-12	Rancho Gabriella	66	66	1	1	Yes
FF-13	Rancho Gabriella	70	66	4	6	Yes
FF-14	Roseview	56	49	6	11	Yes
FF-15	Ashton Ranch	75	82	7	10	Yes

The model calibration results indicated that the model provided a good estimate of the operating conditions of the City's existing water distribution system. Thirteen out of 15 hydrant locations met the pressure calibration goals. FF-4 and FF-8 did not meet the calibrations goals. This could be attributed to the following:

- The actual pressure in FF-4 was much lower than the modeled pressure. This could have been the result of an unidentified PRV in the line which reduced the pressure.
- The fire flow test at FF-8 might have been conducted on the hydrant linked to wrong pipeline on Greenway Road.

During the calibration, it was also revealed that some of the fire flow hydrants were located in different WSF service areas than assumed before the fire testing was performed. Updated GIS information was not received until after fire flow tests were

performed, so the information could not be updated before the fire flow testing. Based on the updated GIS information, FF-7 actually lied in the Ashton Ranch service area instead of the Mountain Vista service area and, similarly, FF-3 lied in the Rancho Gabriella service area instead of the Roseview service area. The accuracy of the model, however, was considered sufficient to perform system-wide evaluations for master planning purposes, including responses during extreme stress conditions such as fire flow or peak hour demands.

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A. Fire Flow Test Results

WESTERN STATES FIRE PROTECTION CO.

2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 67

Pitot Reading: 55.00

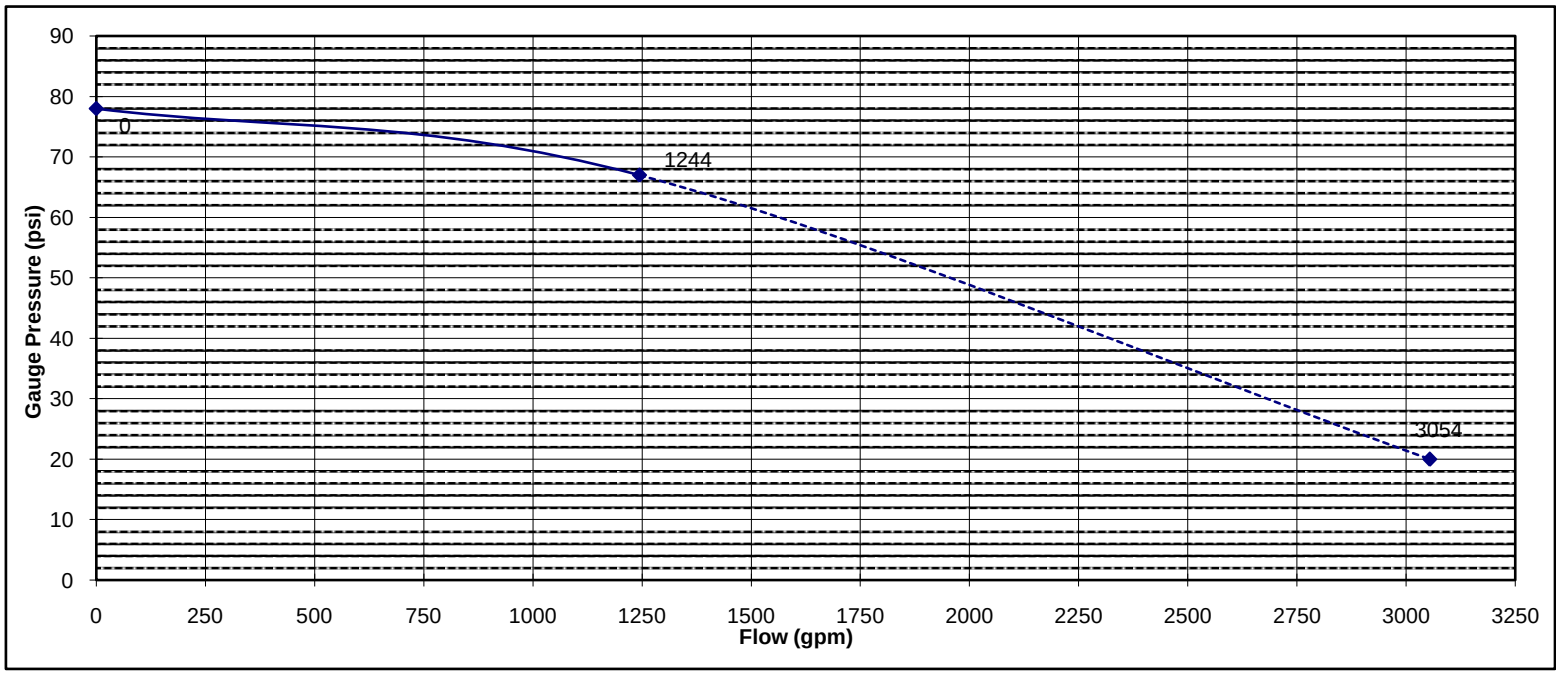
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	67	psi @	1244.4	gpm
Available flow @	20	psi --	3053.9	gpm

Flow at 20 psi: 3053.9 gpm



Comments:

NOTES:

1. Flowing hydrant is assumed to be on a circulating main or downstream of the pressure test hydrant on a dead-end system.
2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.
2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 70.00

Residual Pressure: 61

Pitot Reading: 55.00

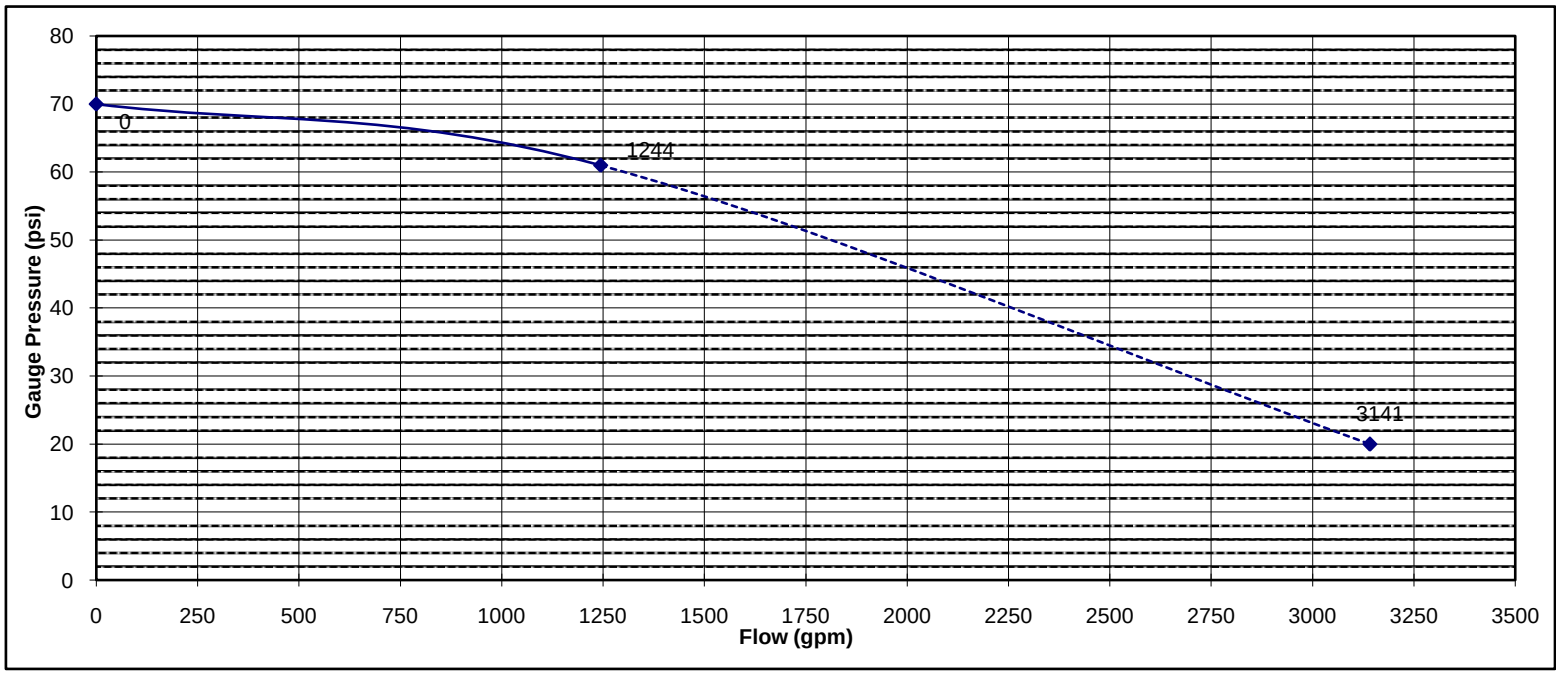
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	70	psi @	0	gpm
Residual pressure of	61	psi @	1244.4	gpm
Available flow @	20	psi --	3141.3	gpm

Flow at 20 psi: 3141.3 gpm



Comments:

NOTES:

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3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
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FF-1 / #WTFH4N2WNW010021 / N. 167TH AV & TETHER TR.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 200'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 69

Pitot Reading: 53.00

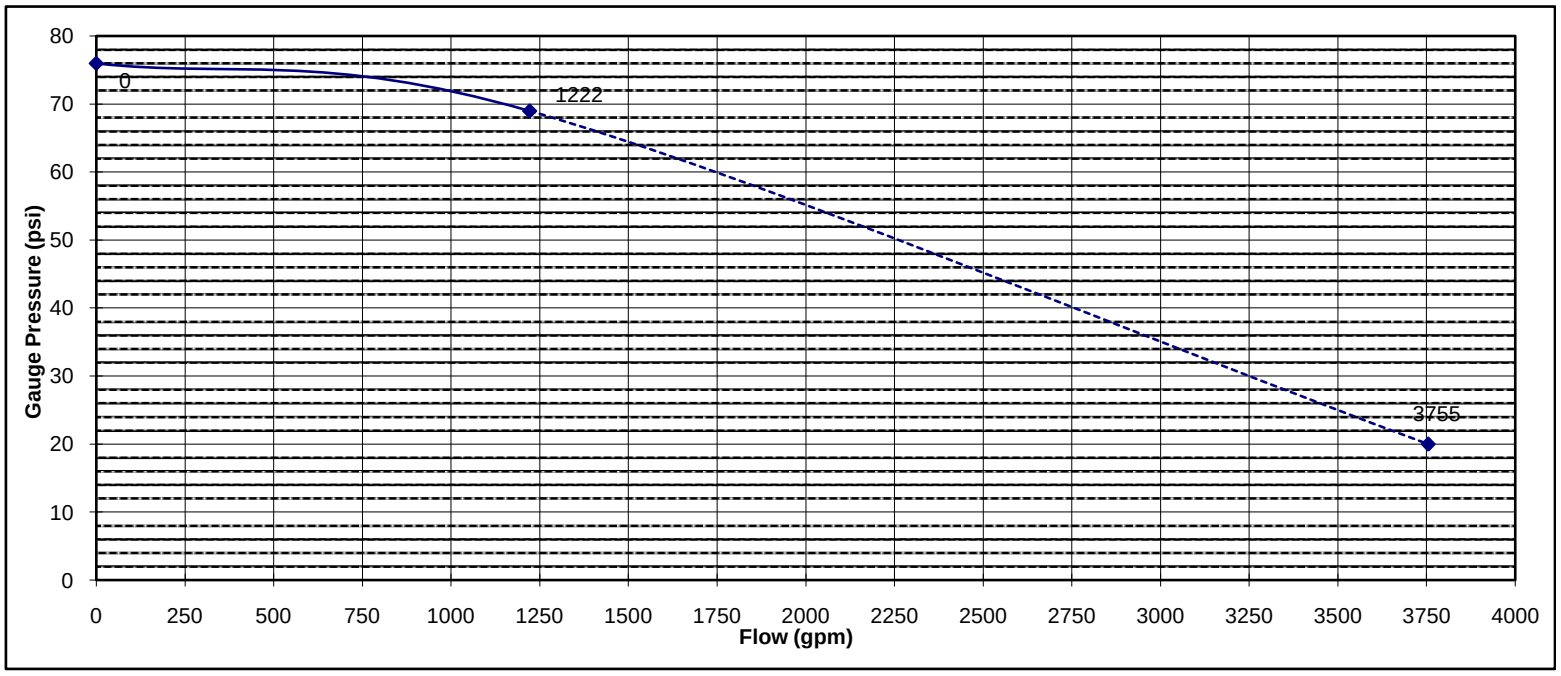
Flow: 1221.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	69	psi @	1221.6	gpm
Available flow @	20	psi --	3754.8	gpm

Flow at 20 psi: 3754.8 gpm



Comments:

NOTES:

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2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

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LOCATION **Malcolm Pirnie, Inc.**
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Phoenix, Az. 85008-6945
FF-2 / WTFH5N2WSW350016 / W SPUR DR & N 175TH LN

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 100.00

Residual Pressure: 87

Pitot Reading: 72.00

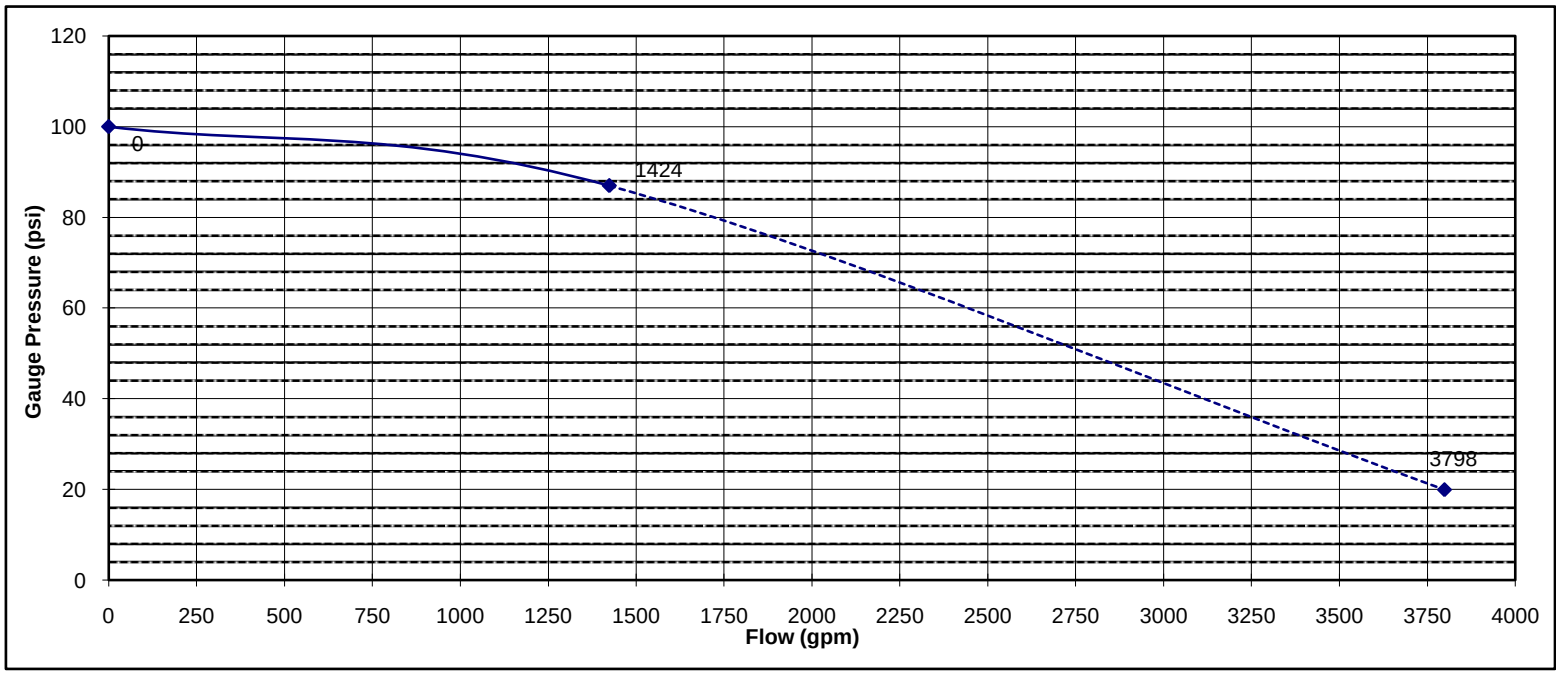
Flow: 1423.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	100	psi @	0	gpm
Residual pressure of	87	psi @	1423.8	gpm
Available flow @	20	psi --	3798.2	gpm

Flow at 20 psi: 3798.2 gpm



Comments:

NOTES:

1. Flowing hydrant is assumed to be on a circulating main or downstream of the pressure test hydrant on a dead-end system.
2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-2 / WTFH5N2WSW350016 / W SPUR DR & N 175TH LN

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 100.00

Residual Pressure: 88

Pitot Reading: 72.00

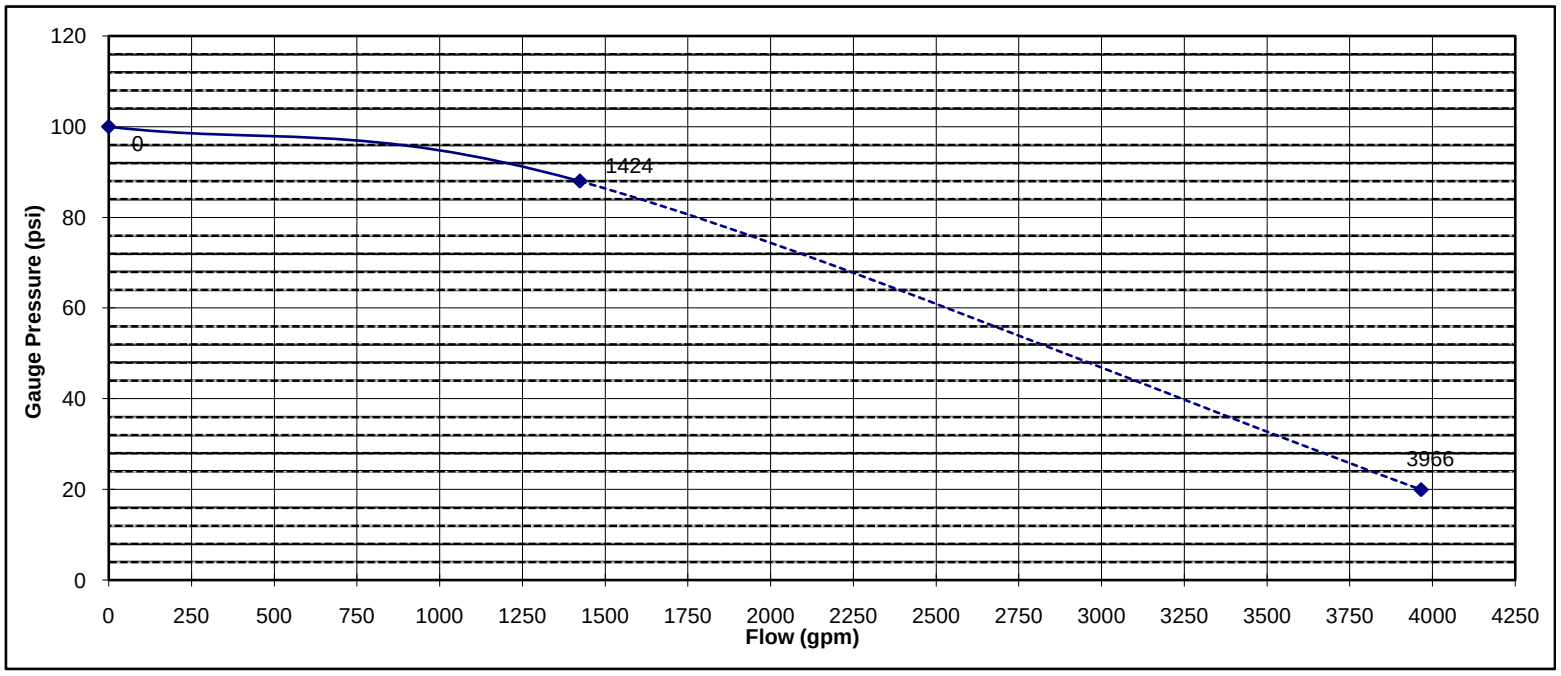
Flow: 1423.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	100	psi @	0	gpm
Residual pressure of	88	psi @	1423.8	gpm
Available flow @	20	psi --	3966.0	gpm

Flow at 20 psi: 3966.0 gpm



Comments:

NOTES:

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WESTERN STATES FIRE PROTECTION CO.

2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-2 / WTFH5N2WSW350016 / W SPUR DR & N 175TH LN

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 12"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 85

Pitot Reading: 70.00

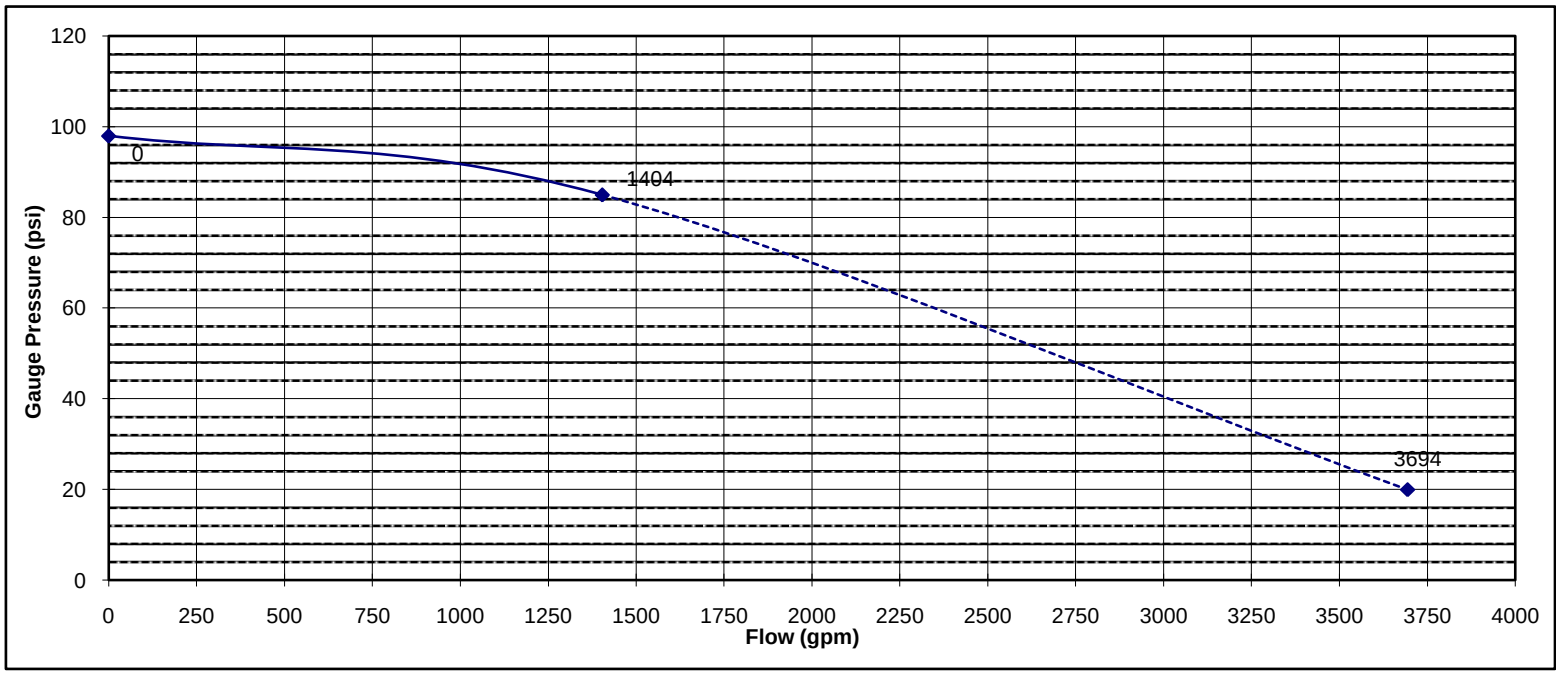
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	85	psi @	1403.9	gpm
Available flow @	20	psi --	3694.3	gpm

Flow at 20 psi: 3694.3 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-3 / WTFH3N1WNE150006 / 133RD & WADDELL - TBIRD

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 84.00

Residual Pressure: 76

Pitot Reading: 63.00

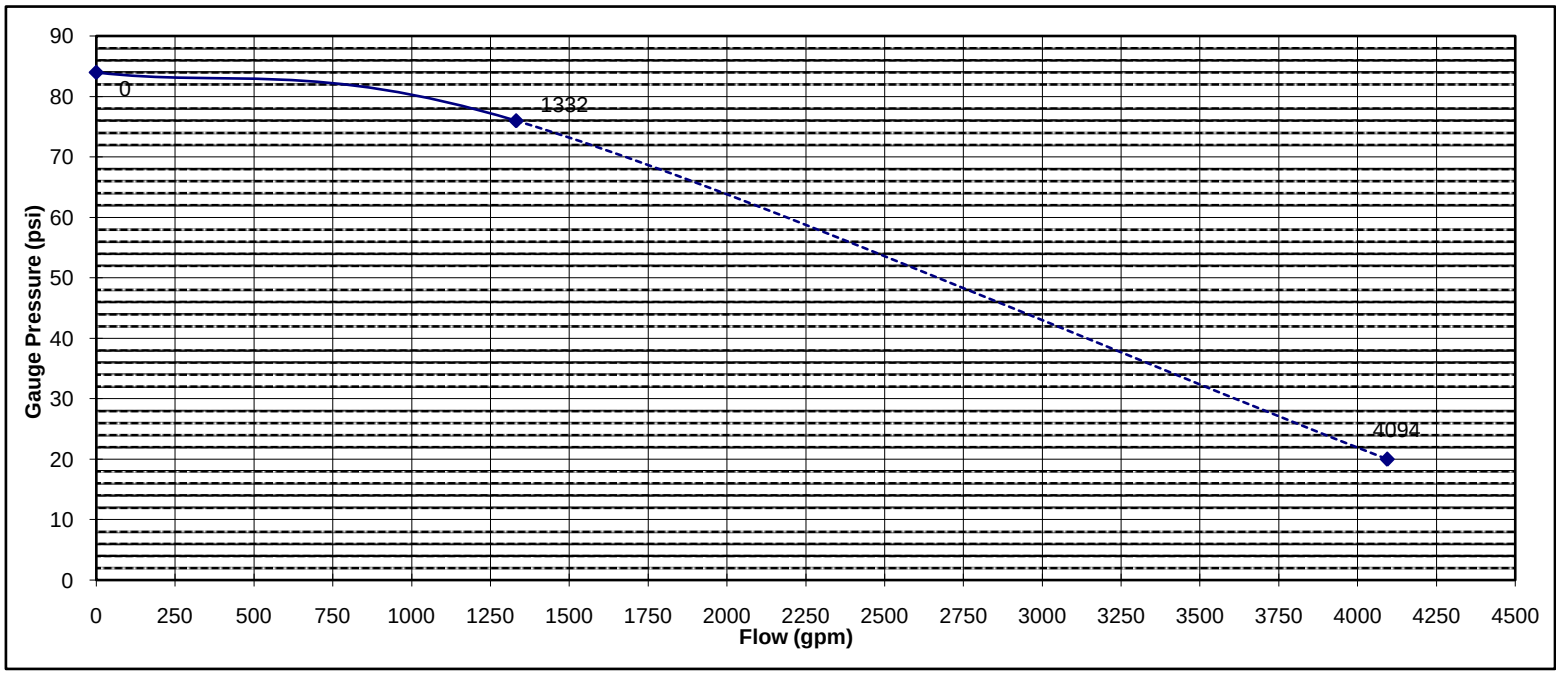
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	84	psi @	0	gpm
Residual pressure of	76	psi @	1331.8	gpm
Available flow @	20	psi --	4093.7	gpm

Flow at 20 psi: 4093.7 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-3 / WTFH3N1WNE150006 / 133RD & WADDELL - TBIRD

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 70

Pitot Reading: 63.00

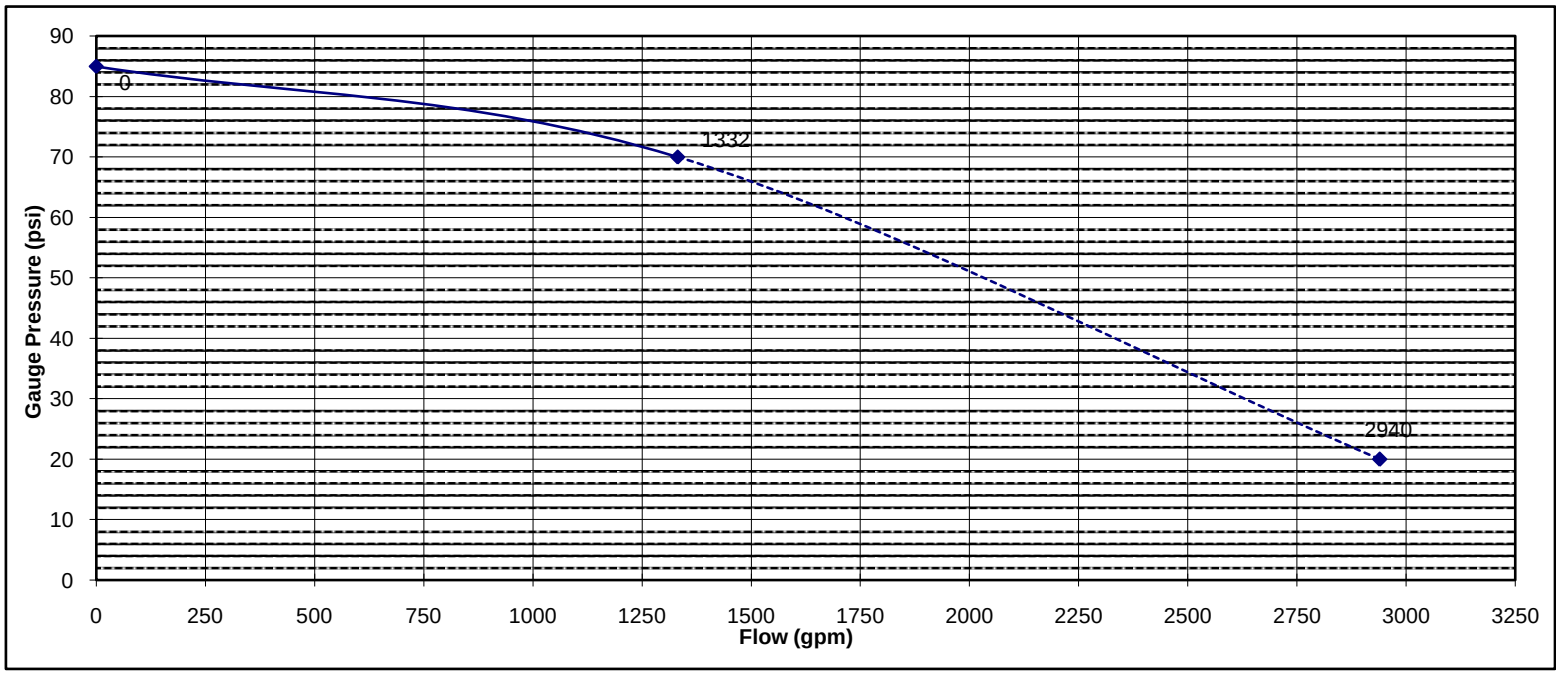
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	70	psi @	1331.8	gpm
Available flow @	20	psi --	2939.9	gpm

Flow at 20 psi: 2939.9 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-3 / WTFH3N1WNE150006 / 133RD & WADDELL - TBIRD

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 87.00

Residual Pressure: 65

Pitot Reading: 57.00

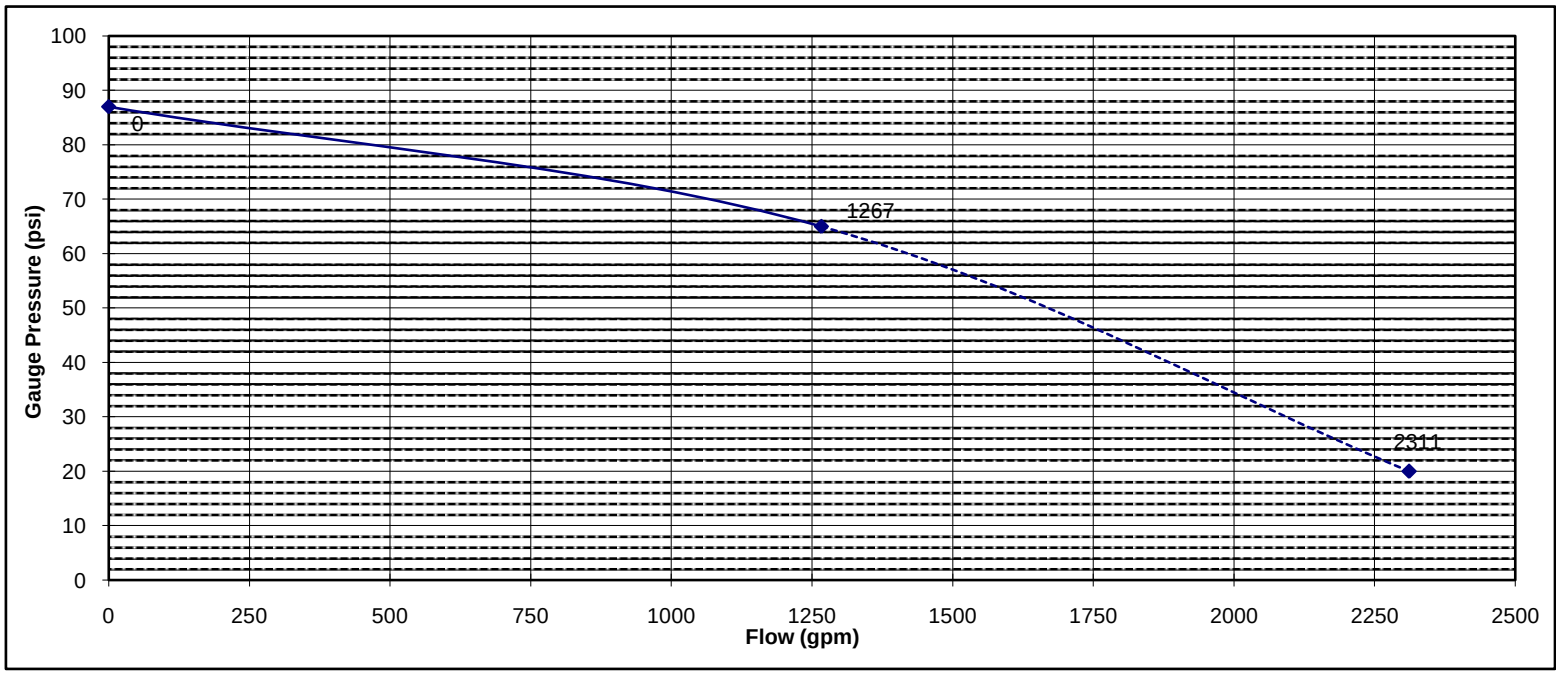
Flow: 1266.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	87	psi @	0	gpm
Residual pressure of	65	psi @	1266.8	gpm
Available flow @	20	psi --	2311.5	gpm

Flow at 20 psi: 2311.5 gpm



Comments:

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Phoenix, AZ 85027
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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 75.00

Residual Pressure: 60

Pitot Reading: 48.00

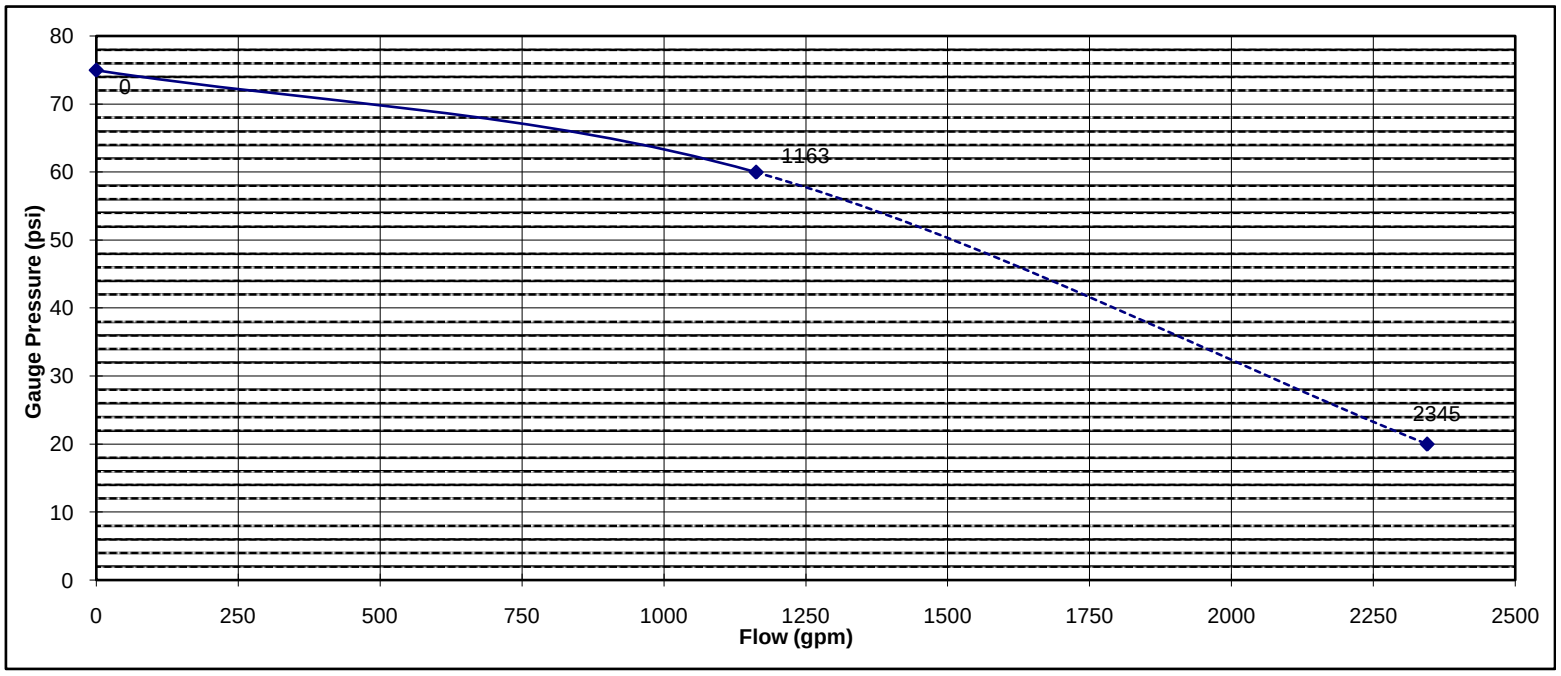
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	75	psi @	0	gpm
Residual pressure of	60	psi @	1162.5	gpm
Available flow @	20	psi --	2344.8	gpm

Flow at 20 psi: 2344.8 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 63

Pitot Reading: 54.00

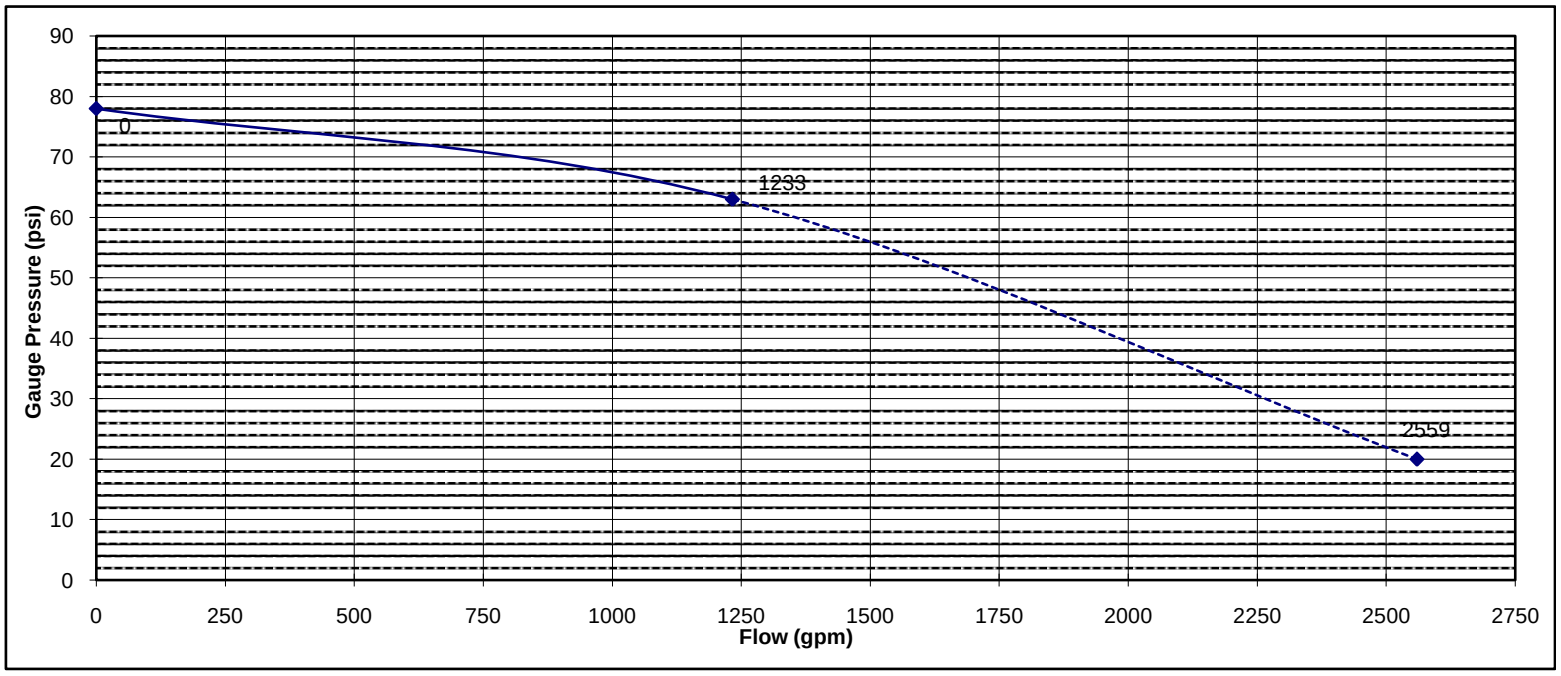
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	63	psi @	1233.0	gpm
Available flow @	20	psi --	2559.4	gpm

Flow at 20 psi: 2559.4 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-4 / WTFH3N1WNE090013 / 140TH & GREENWAY RD.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 60

Pitot Reading: 55.00

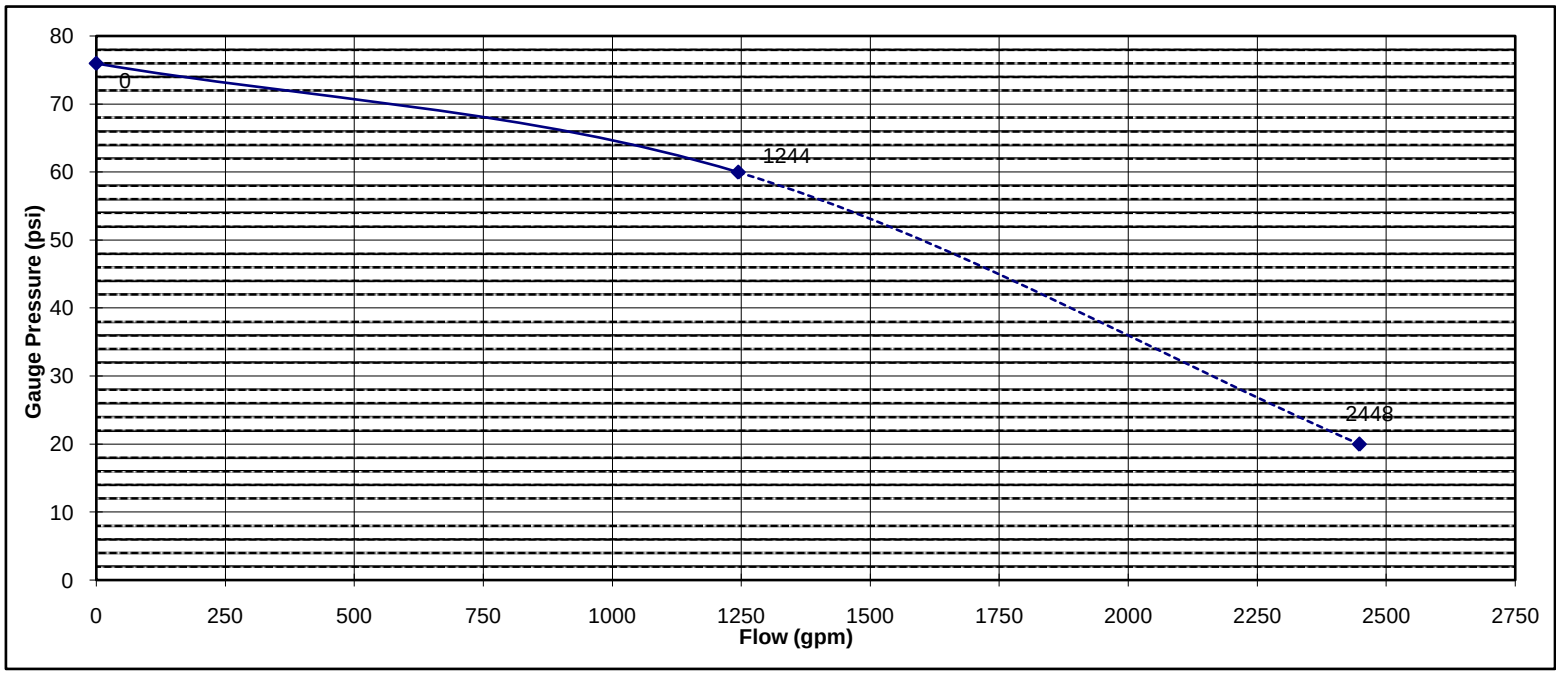
Flow: 1244.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	60	psi @	1244.4	gpm
Available flow @	20	psi --	2447.7	gpm

Flow at 20 psi: 2447.7 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 70

Pitot Reading: 58.00

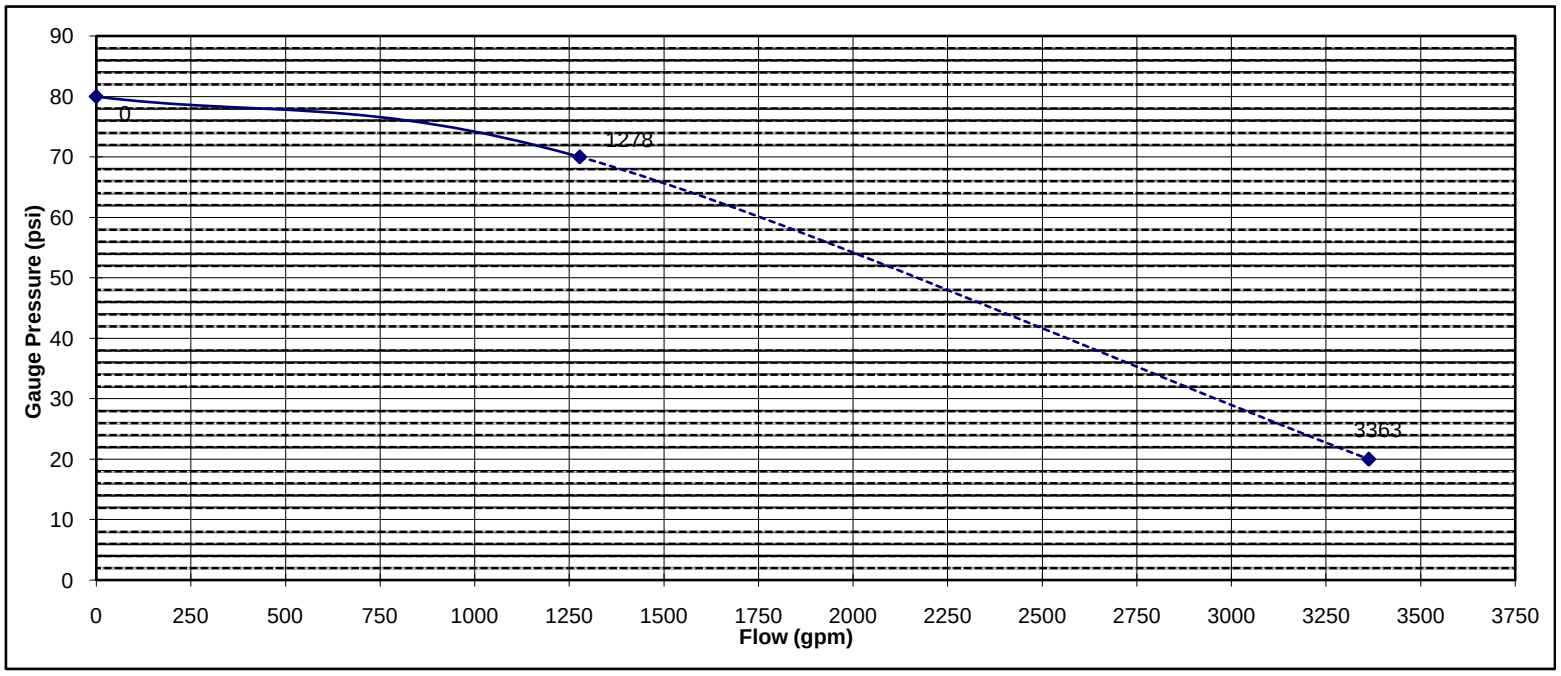
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	3362.7	gpm

Flow at 20 psi: 3362.7 gpm



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Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 74

Pitot Reading: 56.00

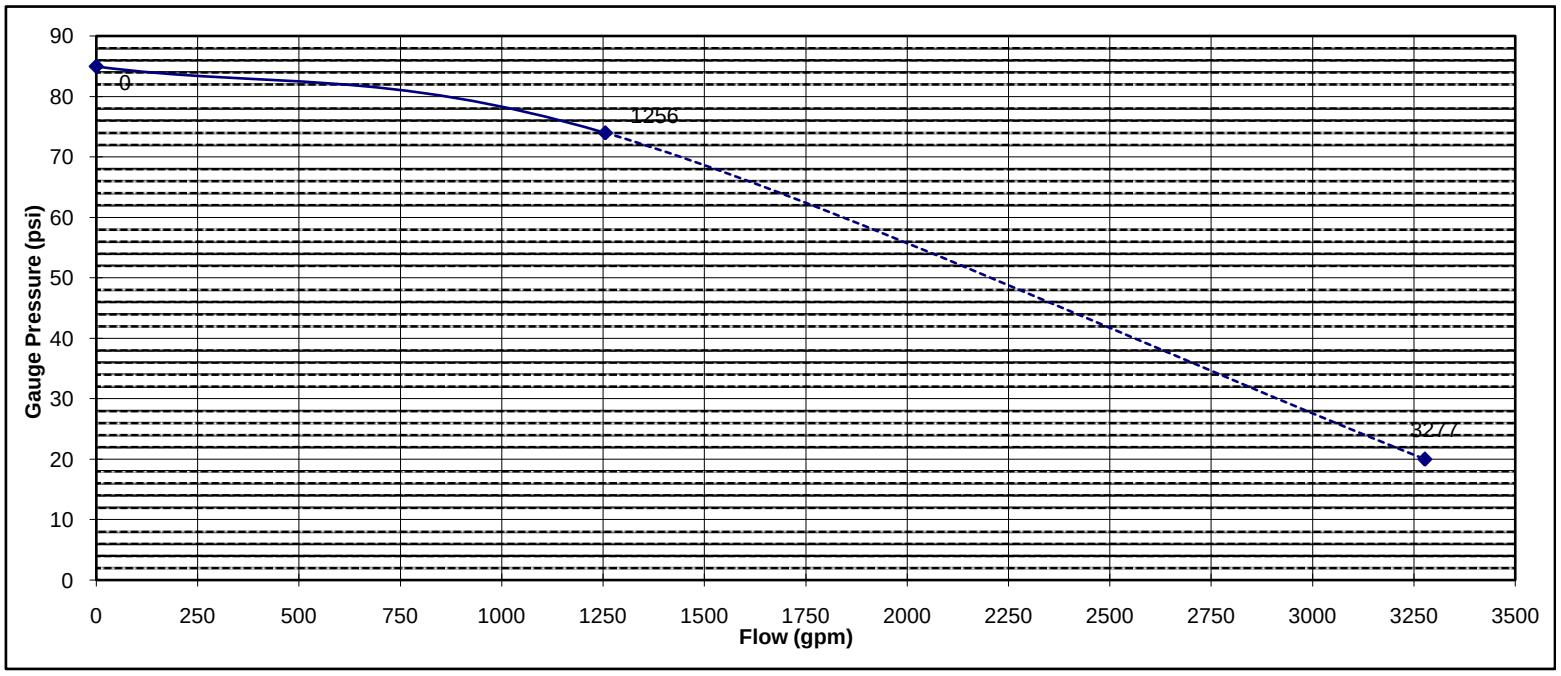
Flow: 1255.7 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	74	psi @	1255.7	gpm
Available flow @	20	psi --	3277.1	gpm

Flow at 20 psi: 3277.1 gpm



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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-5 / WTFH3N1WSE040009 / 142ND BY COURTHOUSE

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 58.00

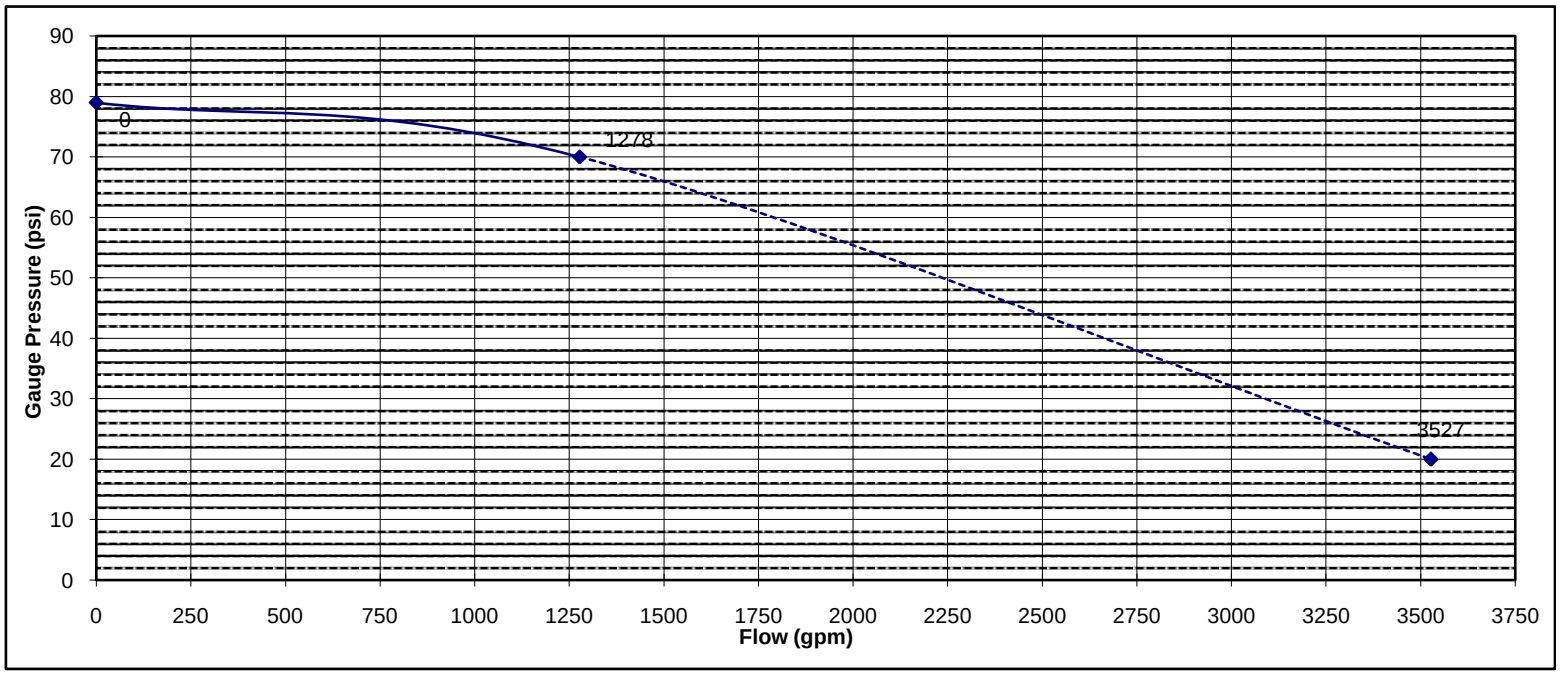
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	3527.4	gpm

Flow at 20 psi: 3527.4 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 74.00

Residual Pressure: 66

Pitot Reading: 48.00

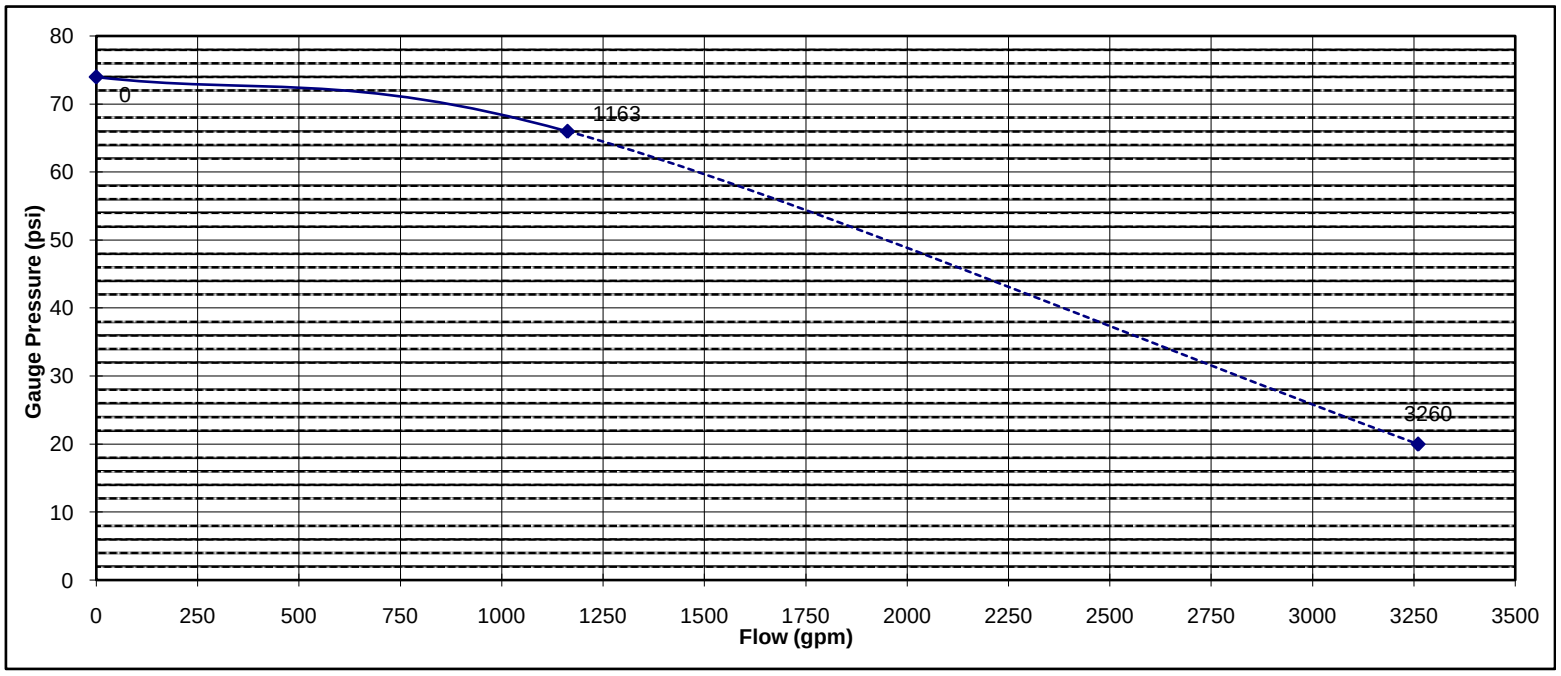
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	74	psi @	0	gpm
Residual pressure of	66	psi @	1162.5	gpm
Available flow @	20	psi --	3260.0	gpm

Flow at 20 psi: 3260.0 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 48.00

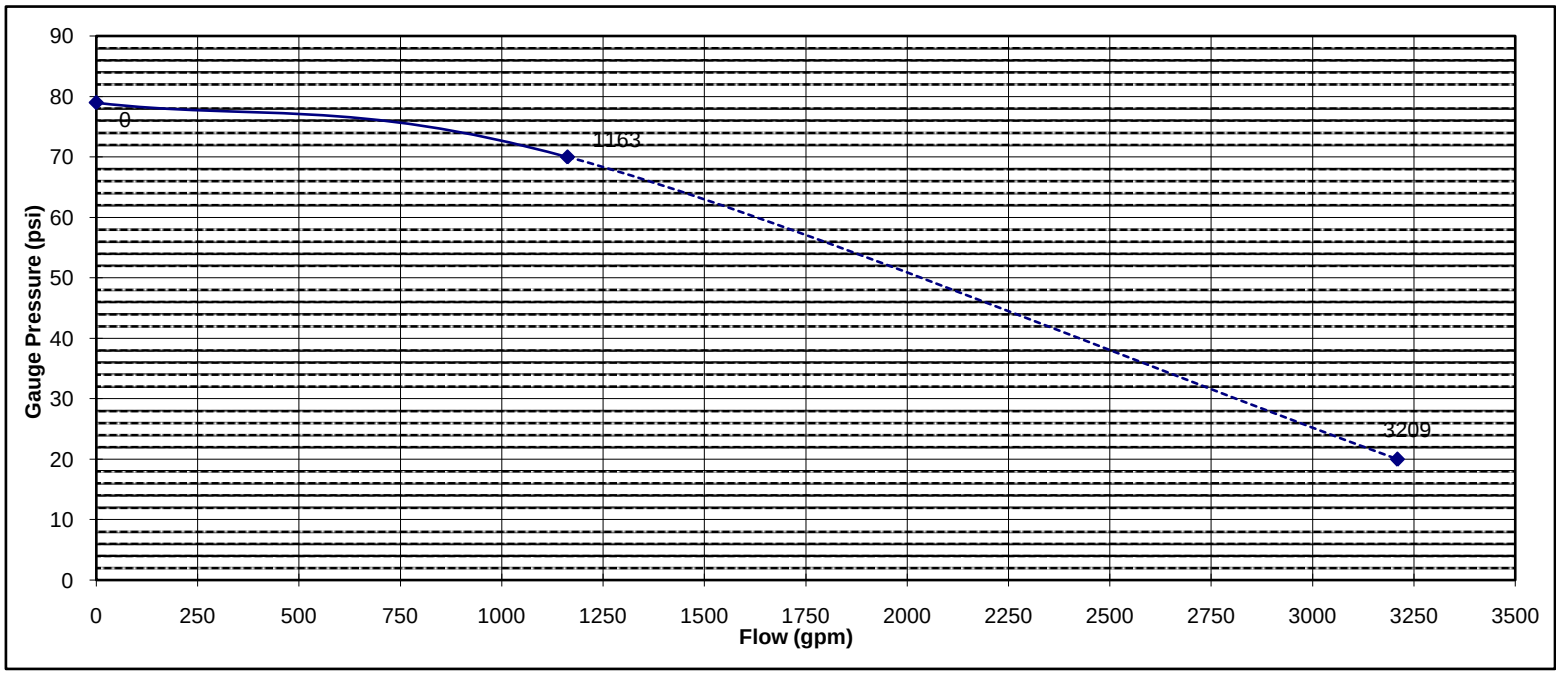
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1162.5	gpm
Available flow @	20	psi --	3209.0	gpm

Flow at 20 psi: 3209.0 gpm



Comments:

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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-6 / WTFH3N1WNW040003 / BULLARD AND 1/2 MI N. OF GNWAY

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 78.00

Residual Pressure: 71

Pitot Reading: 45.00

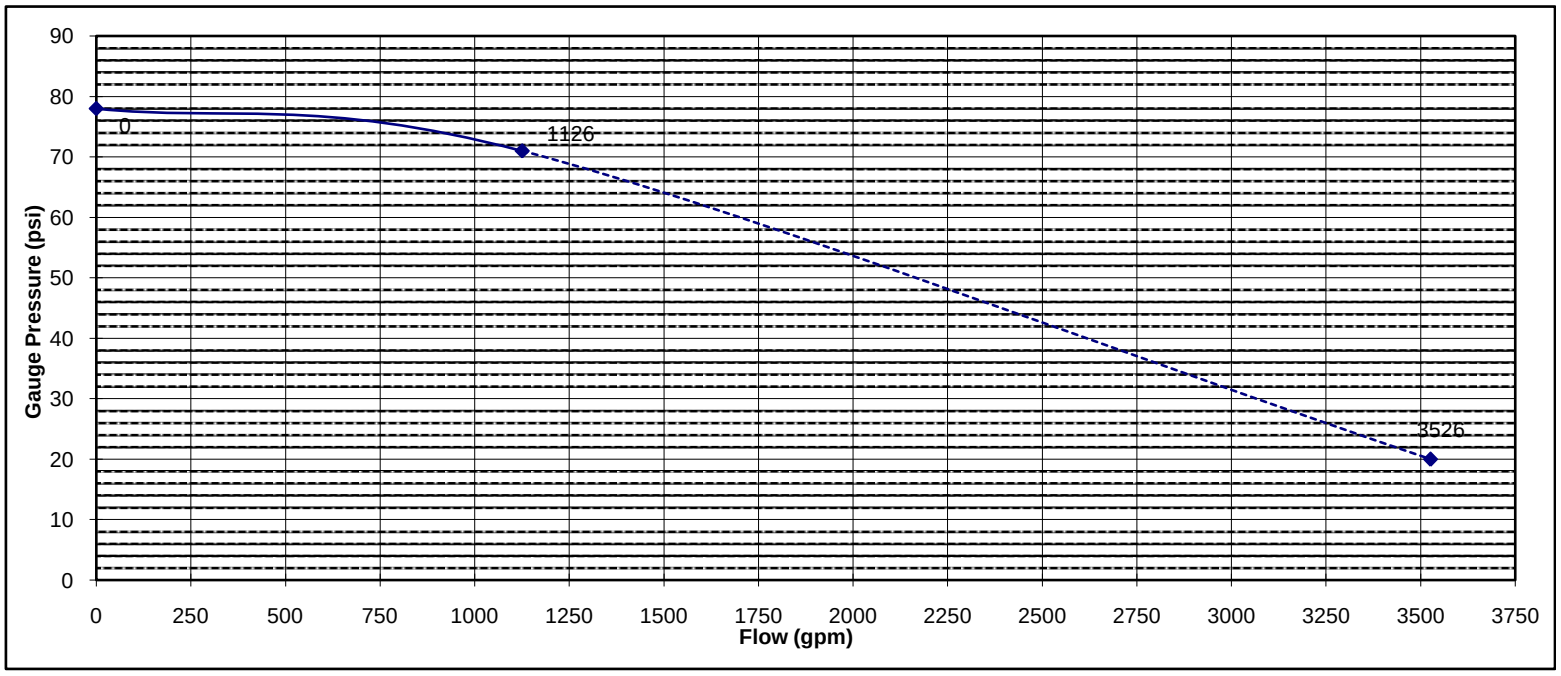
Flow: 1125.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	78	psi @	0	gpm
Residual pressure of	71	psi @	1125.6	gpm
Available flow @	20	psi --	3526.0	gpm

Flow at 20 psi: 3526.0 gpm



Comments:

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Phoenix, AZ 85027
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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 60.00

Residual Pressure: 54

Pitot Reading: 46.00

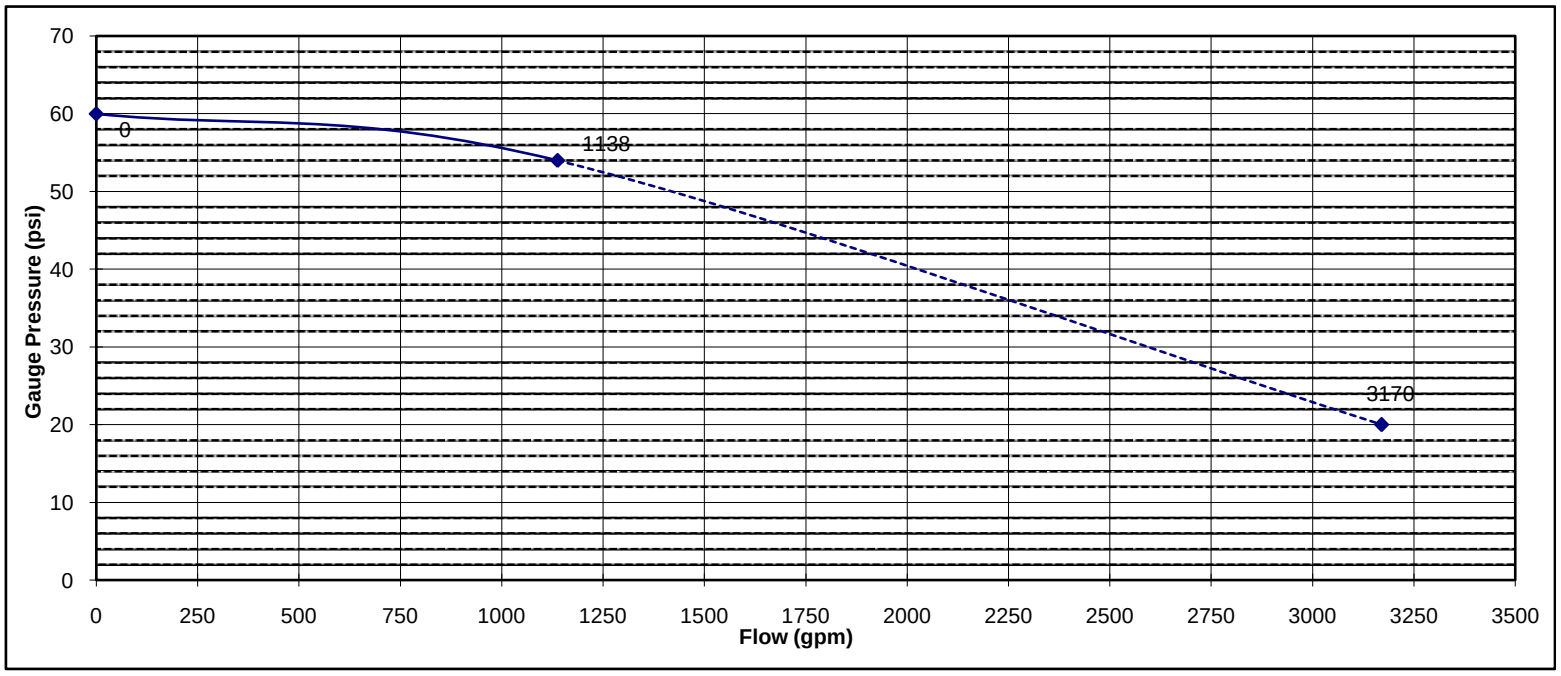
Flow: 1138.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	60	psi @	0	gpm
Residual pressure of	54	psi @	1138.0	gpm
Available flow @	20	psi --	3170.0	gpm

Flow at 20 psi: 3170.0 gpm



Comments:

NOTES:

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3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.
2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 62.00

Residual Pressure: 55

Pitot Reading: 46.00

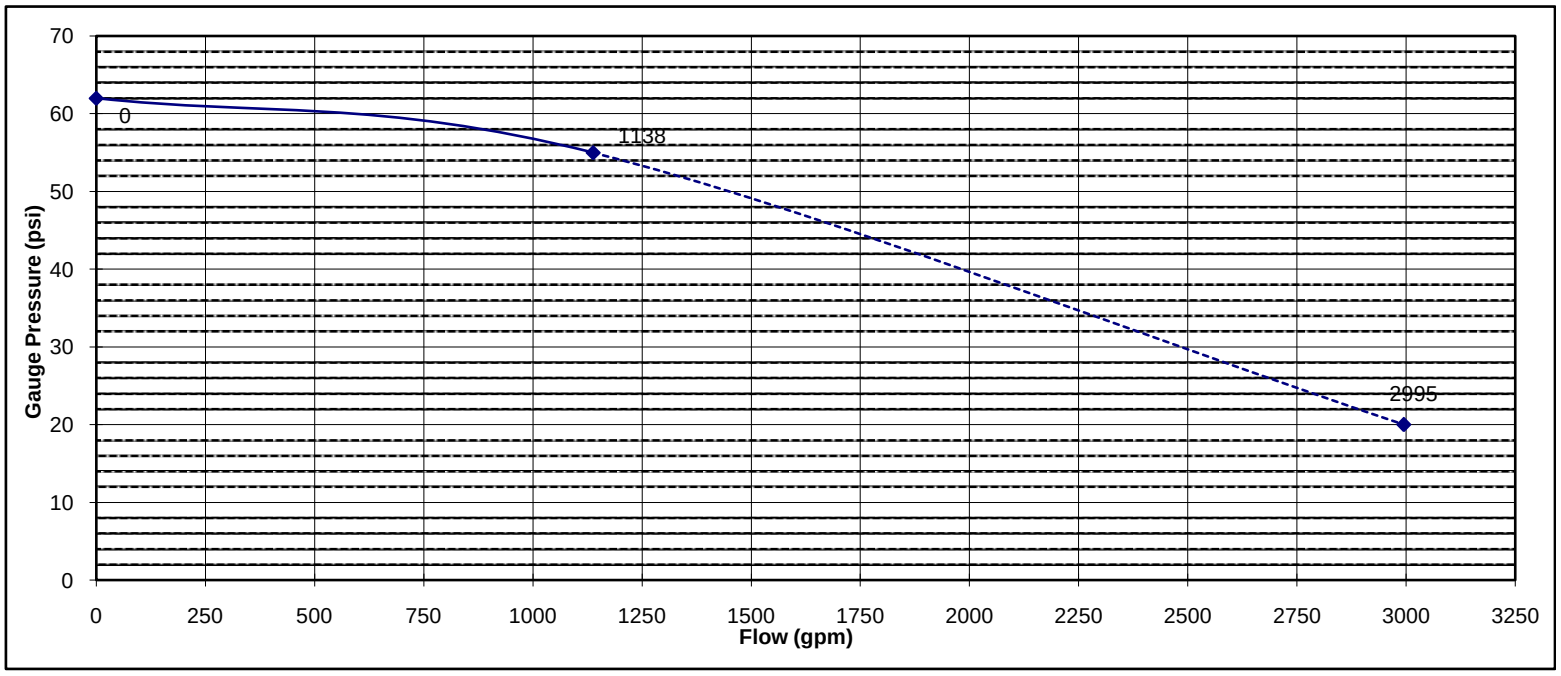
Flow: 1138.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	62	psi @	0	gpm
Residual pressure of	55	psi @	1138.0	gpm
Available flow @	20	psi --	2994.7	gpm

Flow at 20 psi: 2994.7 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-7 / WTFH3N1WNW050002 / REEMS AND 2 BLKS S. OF BELL RD.

DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 62.00

Residual Pressure: 55

Pitot Reading: 45.00

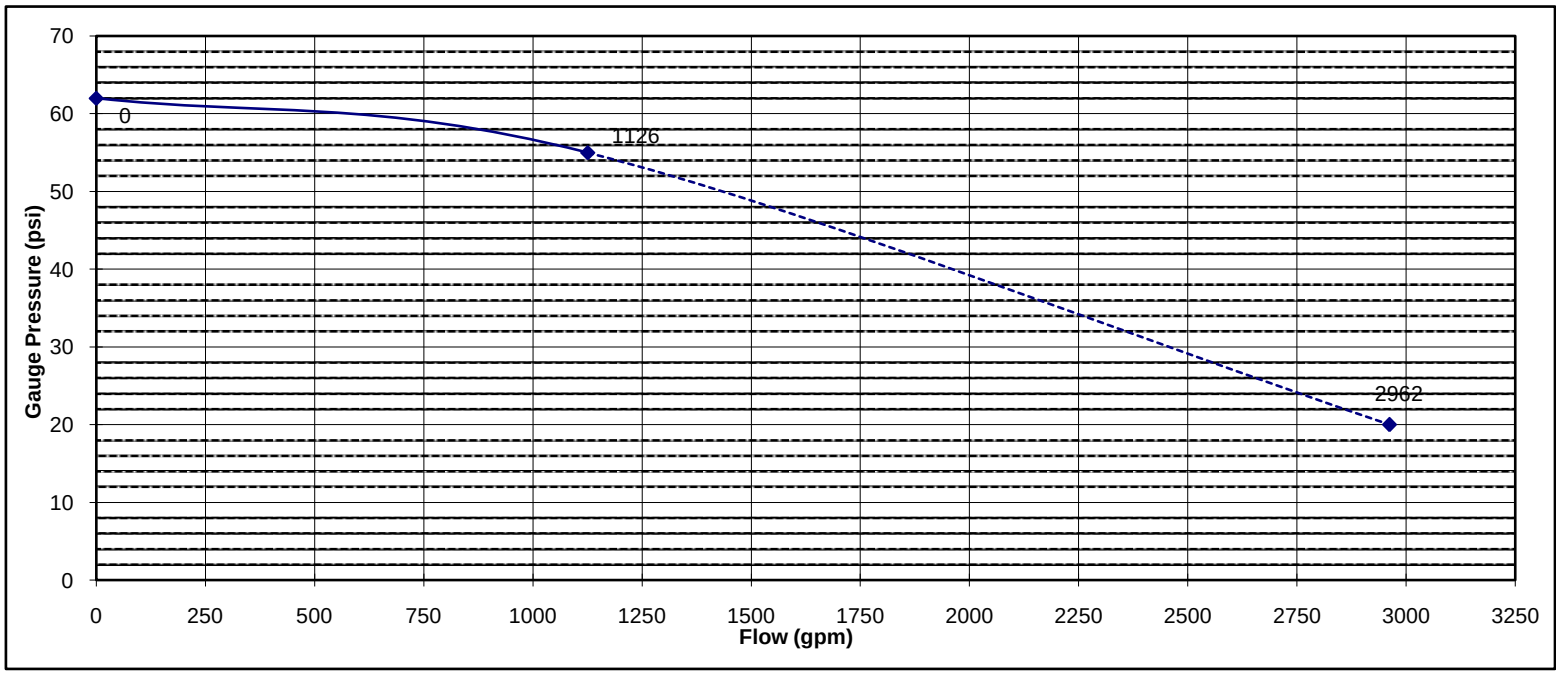
Flow: 1125.6 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	62	psi @	0	gpm
Residual pressure of	55	psi @	1125.6	gpm
Available flow @	20	psi --	2962.0	gpm

Flow at 20 psi: 2962.0 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-8 / WTFH3N1WNE070040 / GREENWAY RD & MTN VISTA RANCH

DATE: 06/08/08
TIME: 07:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 74

Pitot Reading: 65.00

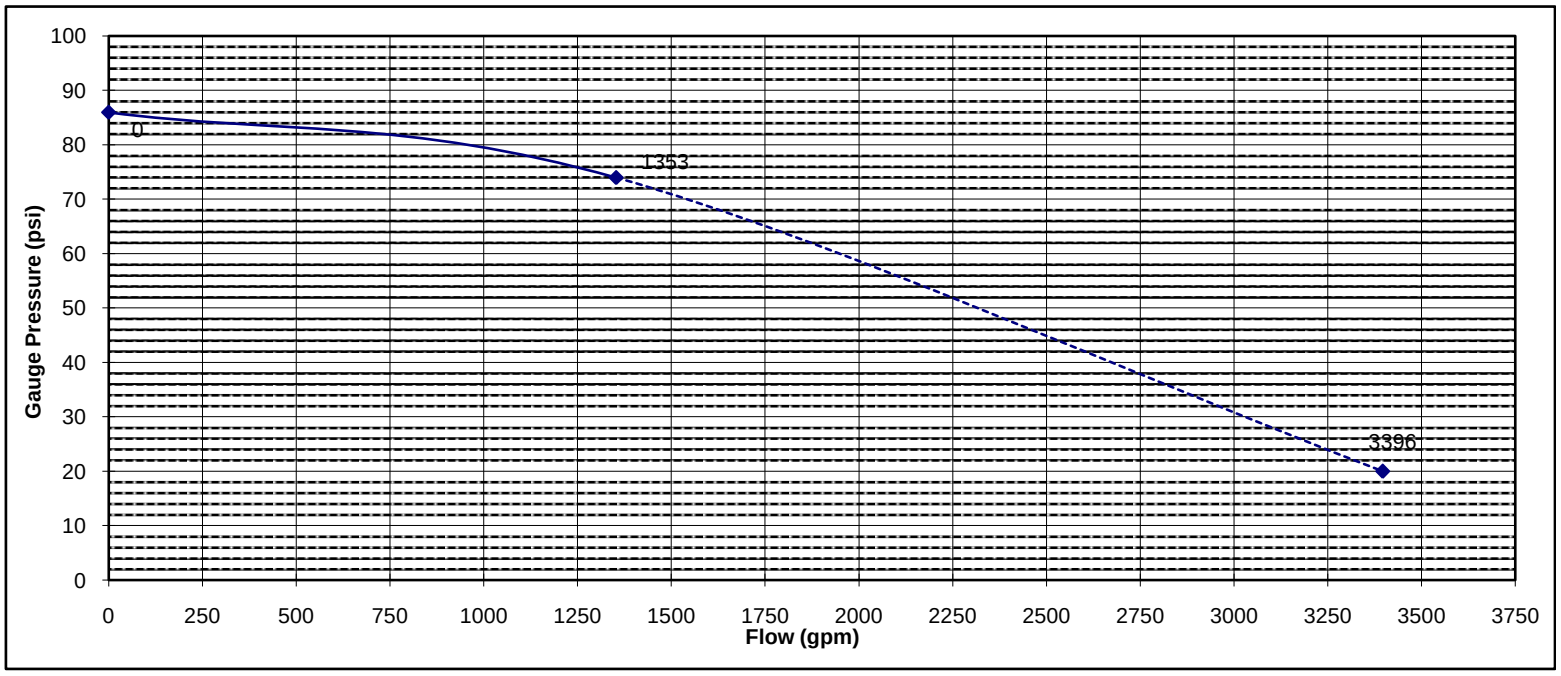
Flow: 1352.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	74	psi @	1352.8	gpm
Available flow @	20	psi --	3396.5	gpm

Flow at 20 psi: 3396.5 gpm



Comments:

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FF-8 / WTFH3N1WNE070040 / GREENWAY RD & MTN VISTA RANCH

DATE: 06/08/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 81.00

Residual Pressure: 72

Pitot Reading: 63.00

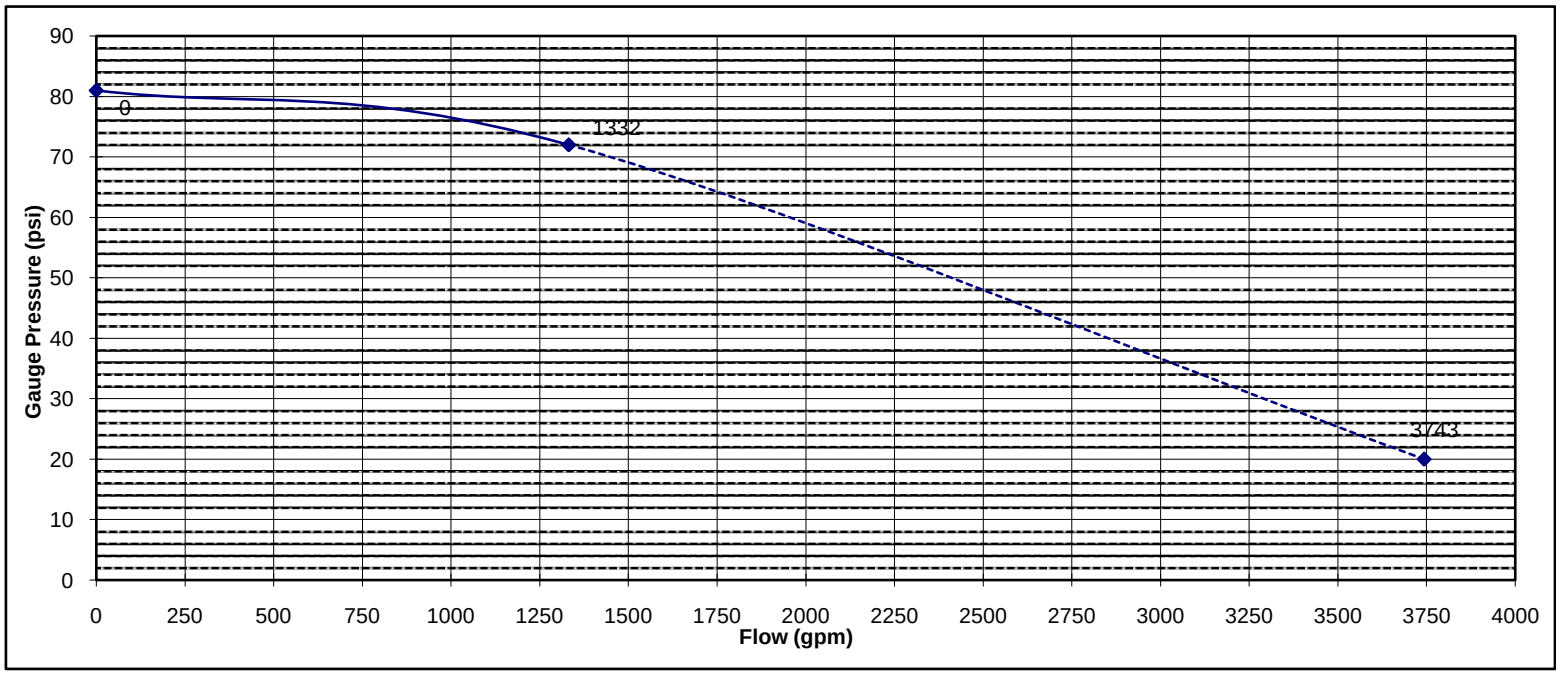
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	81	psi @	0	gpm
Residual pressure of	72	psi @	1331.8	gpm
Available flow @	20	psi --	3743.1	gpm

Flow at 20 psi: 3743.1 gpm



Comments:

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DATE: 06/08/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 82.00

Residual Pressure: 74

Pitot Reading: 63.00

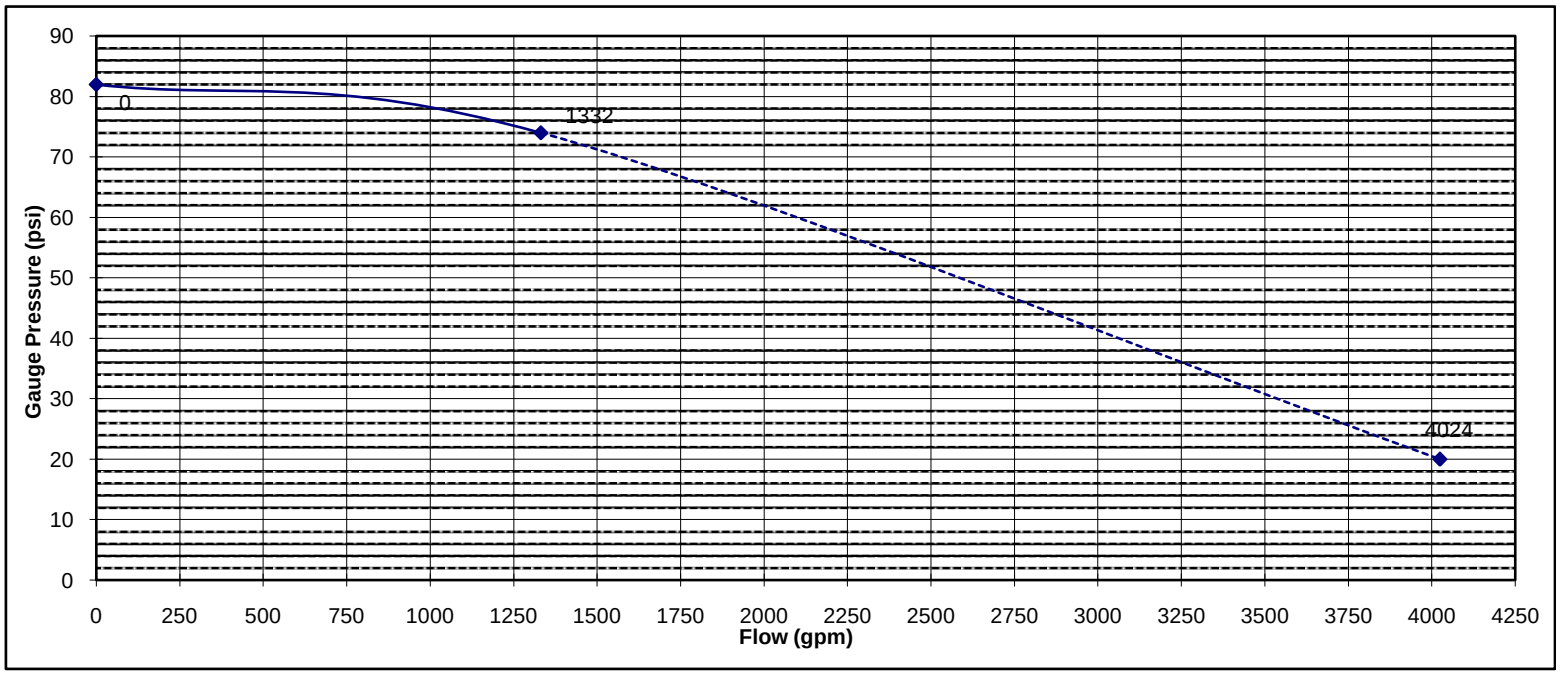
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	82	psi @	0	gpm
Residual pressure of	74	psi @	1331.8	gpm
Available flow @	20	psi --	4024.1	gpm

Flow at 20 psi: 4024.1 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 65

Pitot Reading: 63.00

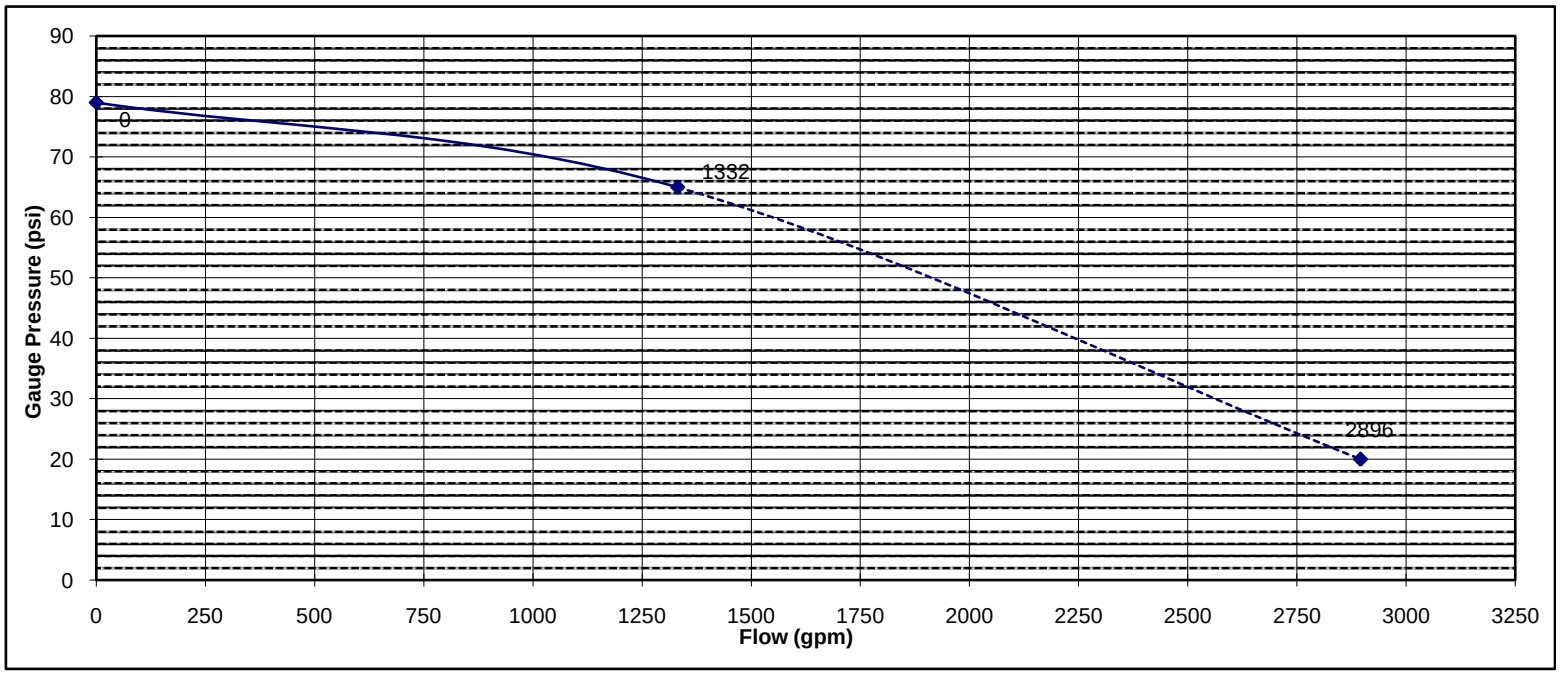
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	65	psi @	1331.8	gpm
Available flow @	20	psi --	2896.0	gpm

Flow at 20 psi: 2896.0 gpm



Comments:

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FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 70

Pitot Reading: 60.00

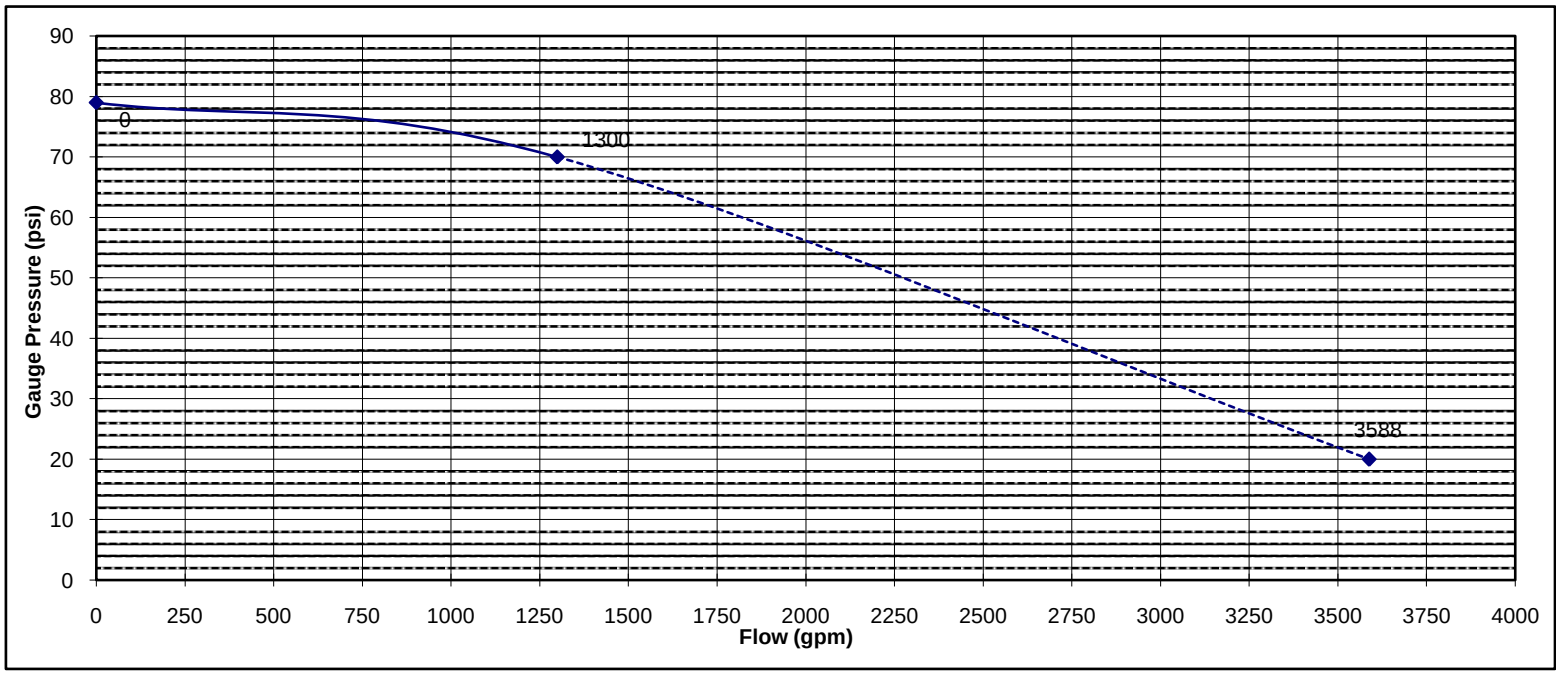
Flow: 1299.7 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	70	psi @	1299.7	gpm
Available flow @	20	psi --	3587.7	gpm

Flow at 20 psi: 3587.7 gpm



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FF-9 / WTFH3N1WNW080043 / REEMS & 1/2 MI S. OF GREENWAY

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 83.00

Residual Pressure: 71

Pitot Reading: 58.00

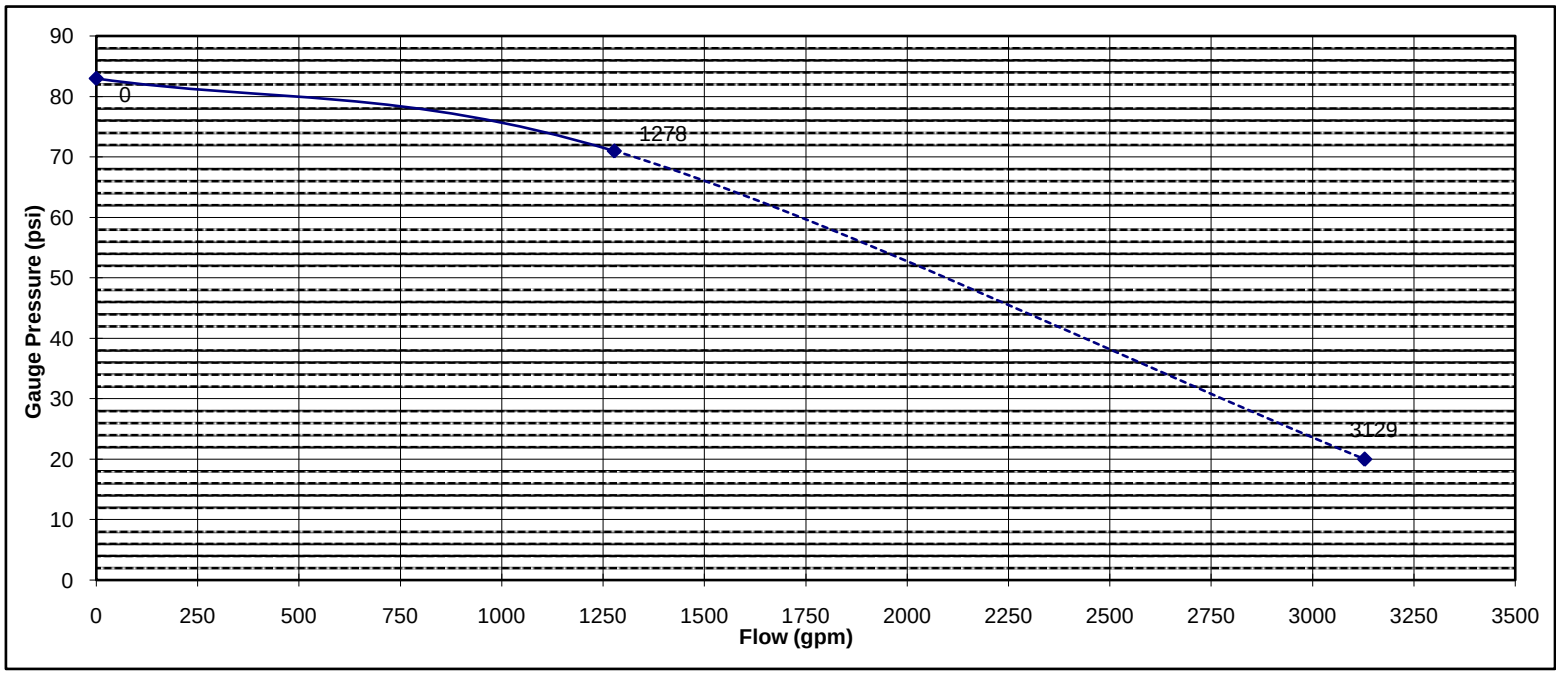
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	83	psi @	0	gpm
Residual pressure of	71	psi @	1277.9	gpm
Available flow @	20	psi --	3128.8	gpm

Flow at 20 psi: 3128.8 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 91.00

Residual Pressure: 82

Pitot Reading: 70.00

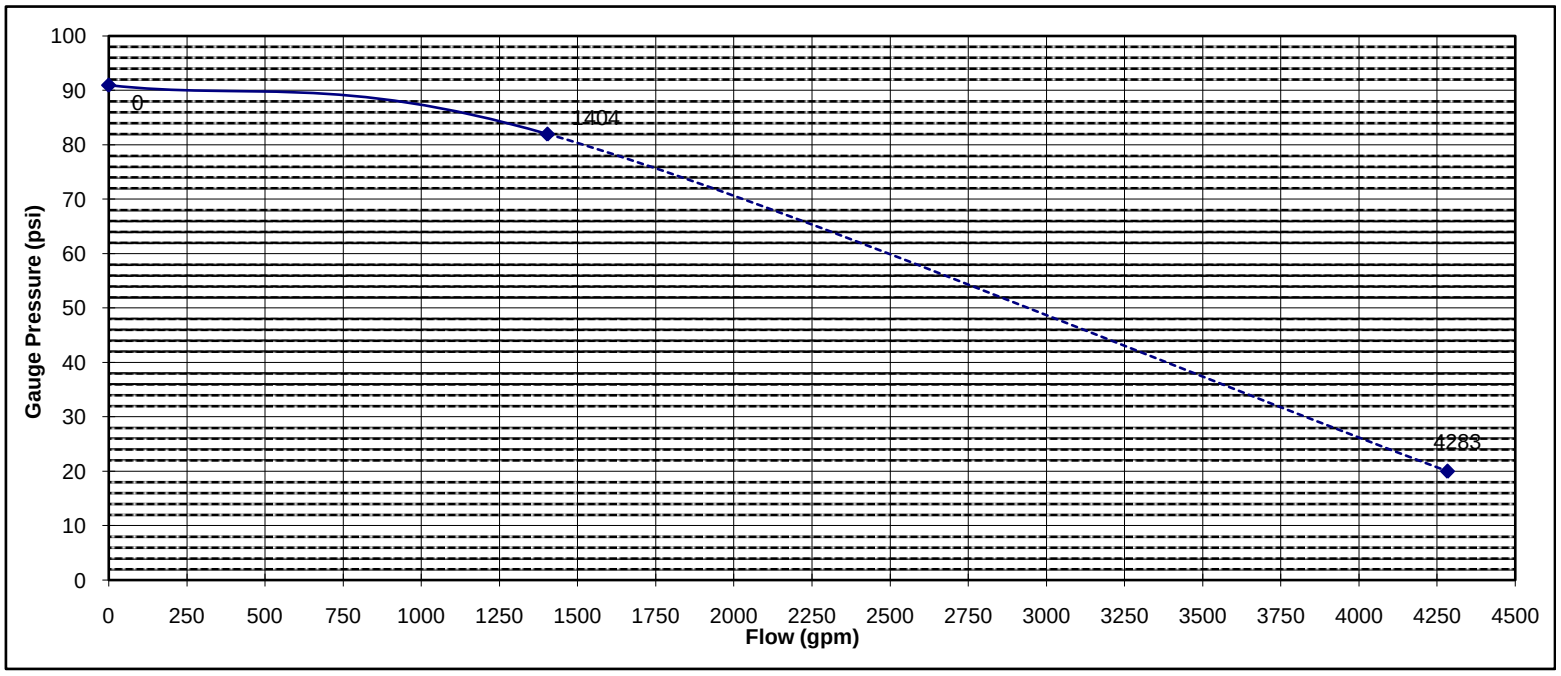
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	91	psi @	0	gpm
Residual pressure of	82	psi @	1403.9	gpm
Available flow @	20	psi --	4282.7	gpm

Flow at 20 psi: 4282.7 gpm



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FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 71

Pitot Reading: 63.00

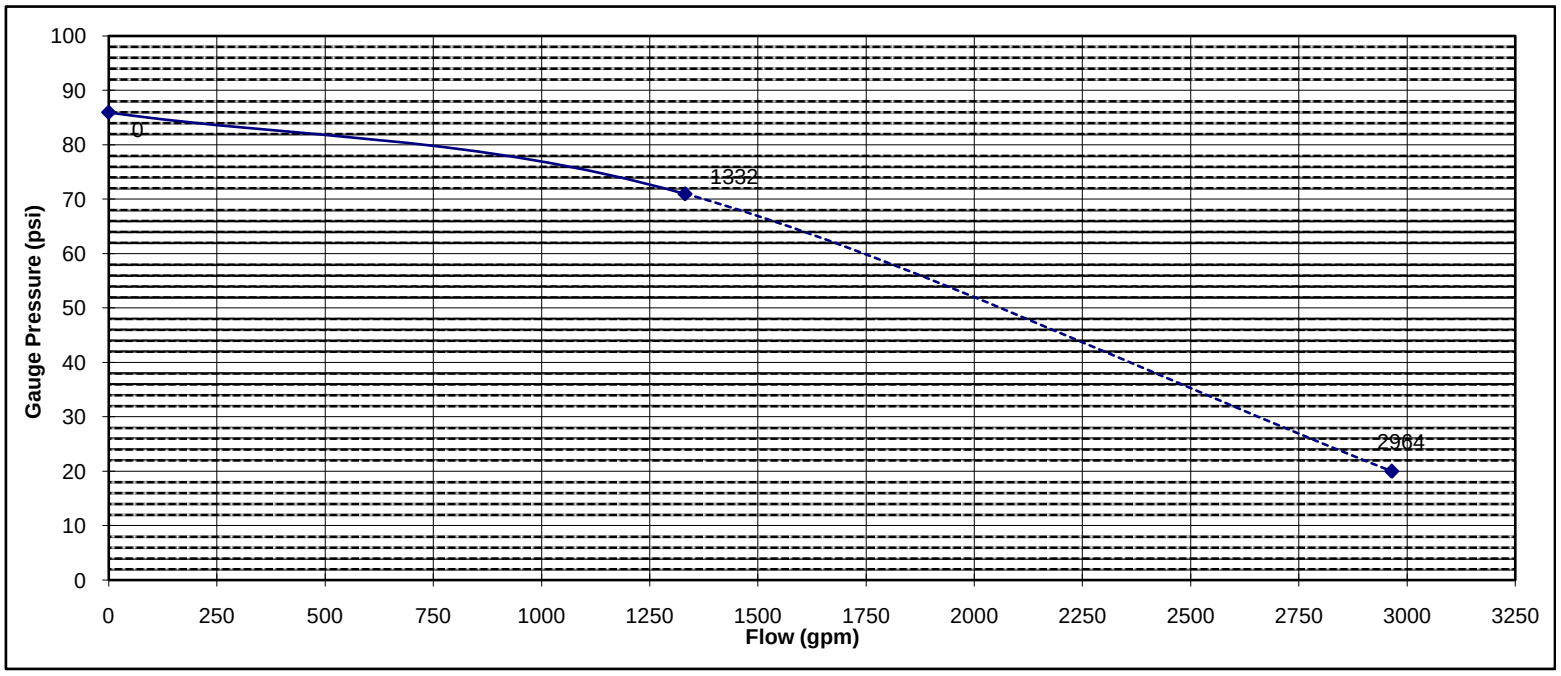
Flow: 1331.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	71	psi @	1331.8	gpm
Available flow @	20	psi --	2964.2	gpm

Flow at 20 psi: 2964.2 gpm



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Phoenix, Az. 85008-6945
FF-10 / WTFH3N1WSE160011 / 140TH AVE & CACTUS RD

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 88.00

Residual Pressure: 75

Pitot Reading: 64.00

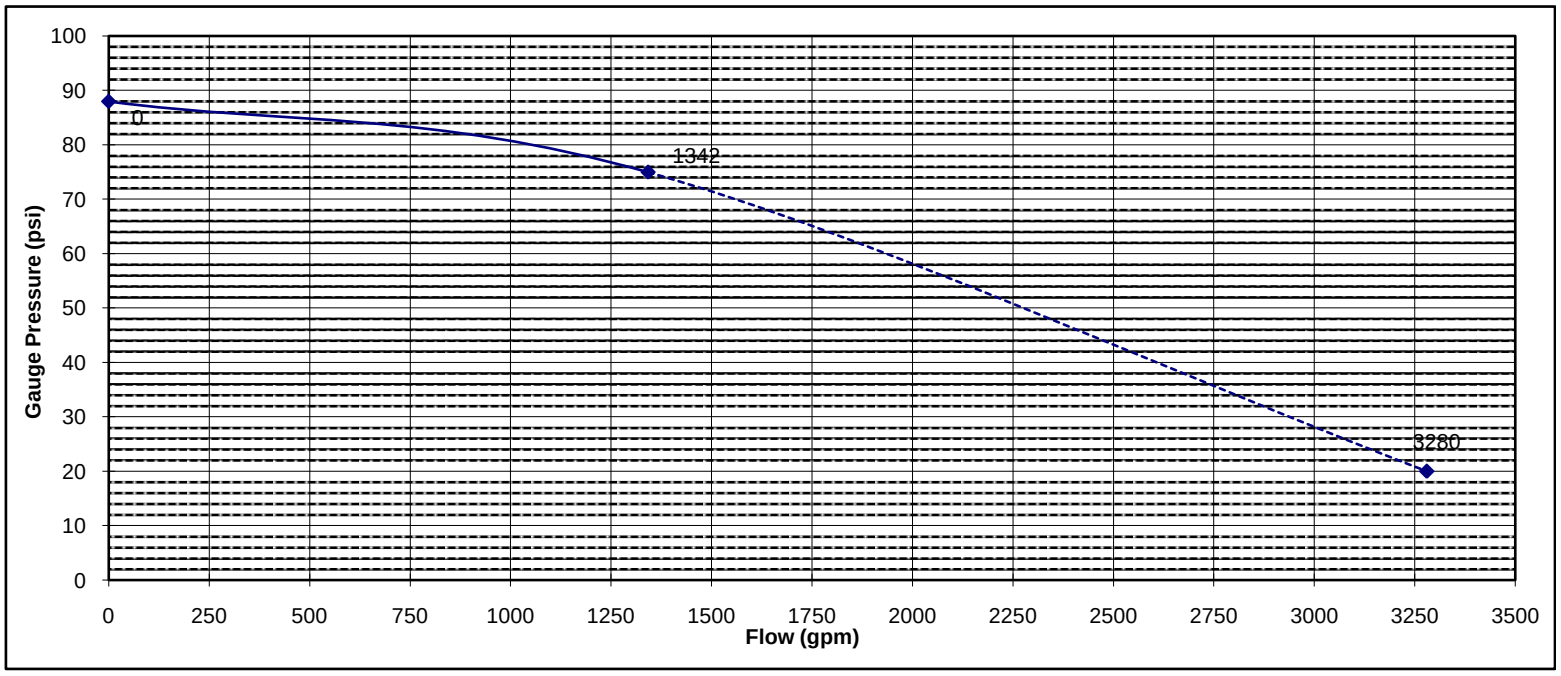
Flow: 1342.4 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	88	psi @	0	gpm
Residual pressure of	75	psi @	1342.4	gpm
Available flow @	20	psi --	3280.1	gpm

Flow at 20 psi: 3280.1 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 72.00

Residual Pressure: 64

Pitot Reading: 48.00

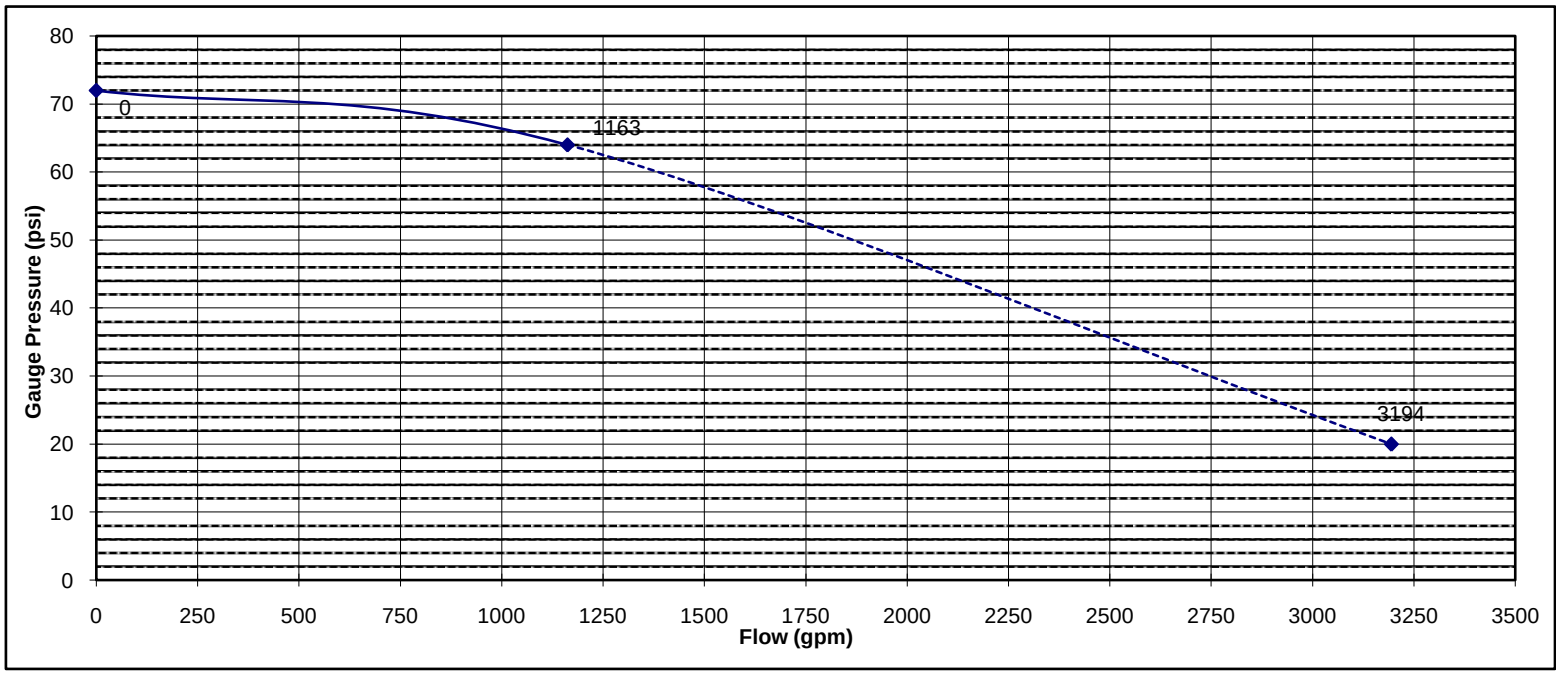
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	72	psi @	0	gpm
Residual pressure of	64	psi @	1162.5	gpm
Available flow @	20	psi --	3194.3	gpm

Flow at 20 psi: 3194.3 gpm



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FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 69.00

Residual Pressure: 55

Pitot Reading: 54.00

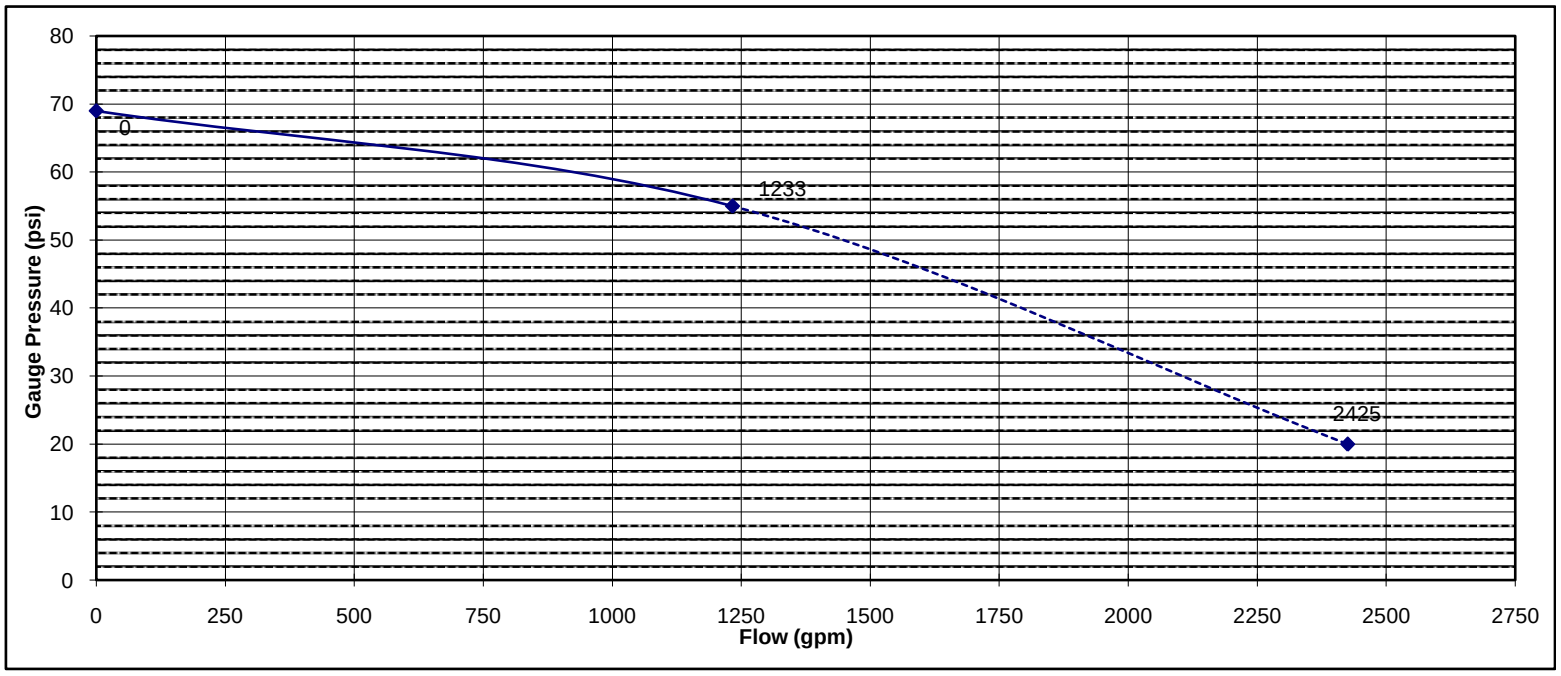
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	69	psi @	0	gpm
Residual pressure of	55	psi @	1233.0	gpm
Available flow @	20	psi --	2425.3	gpm

Flow at 20 psi: 2425.3 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-11 / WTFH3N1WNW170013 / NEC OF SWEETWATER & NFP BL

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 74.00

Residual Pressure: 60

Pitot Reading: 54.00

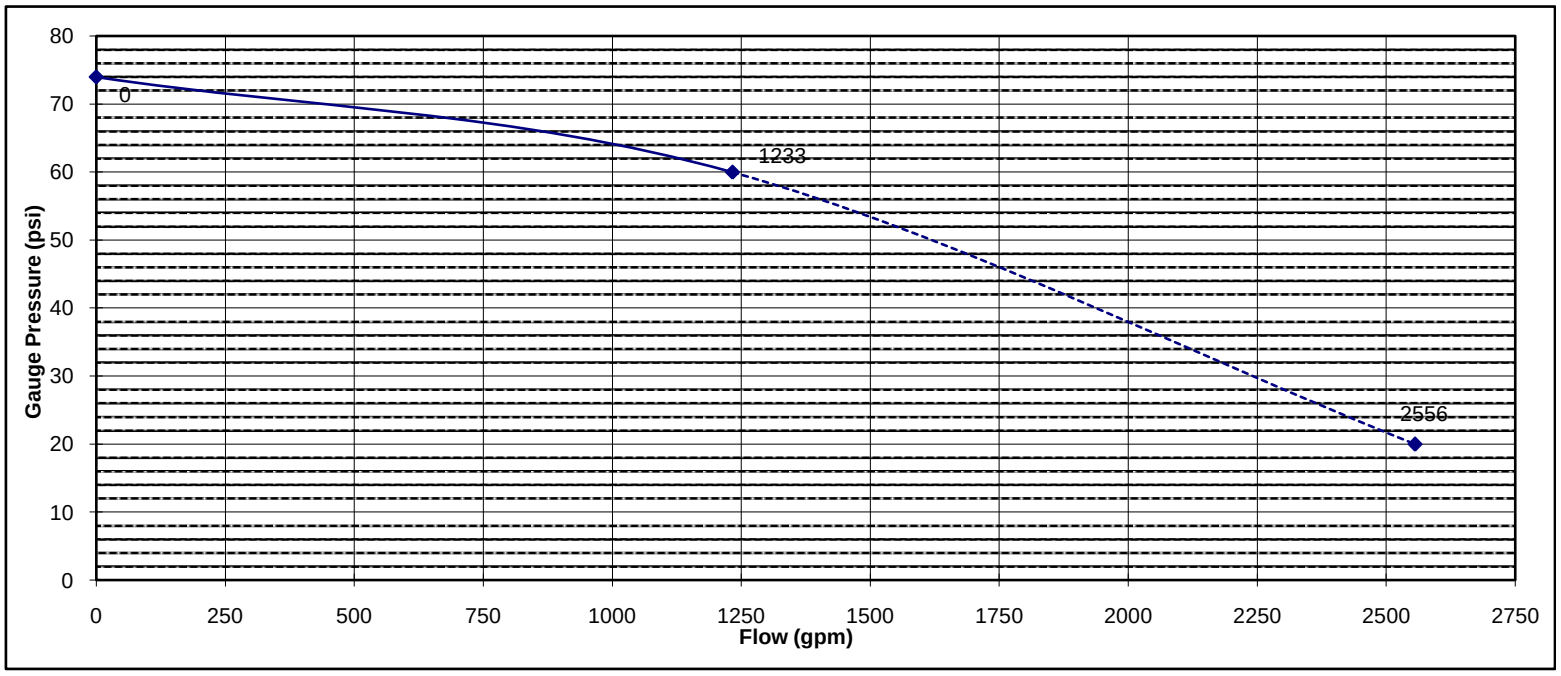
Flow: 1233.0 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	74	psi @	0	gpm
Residual pressure of	60	psi @	1233.0	gpm
Available flow @	20	psi --	2556.0	gpm

Flow at 20 psi: 2556.0 gpm



Comments:

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4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-12 / WTFH3N1WSE170006 / W. CACTUS & 2 BLKS E. OF 151AVE

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 79.00

Residual Pressure: 71

Pitot Reading: 48.00

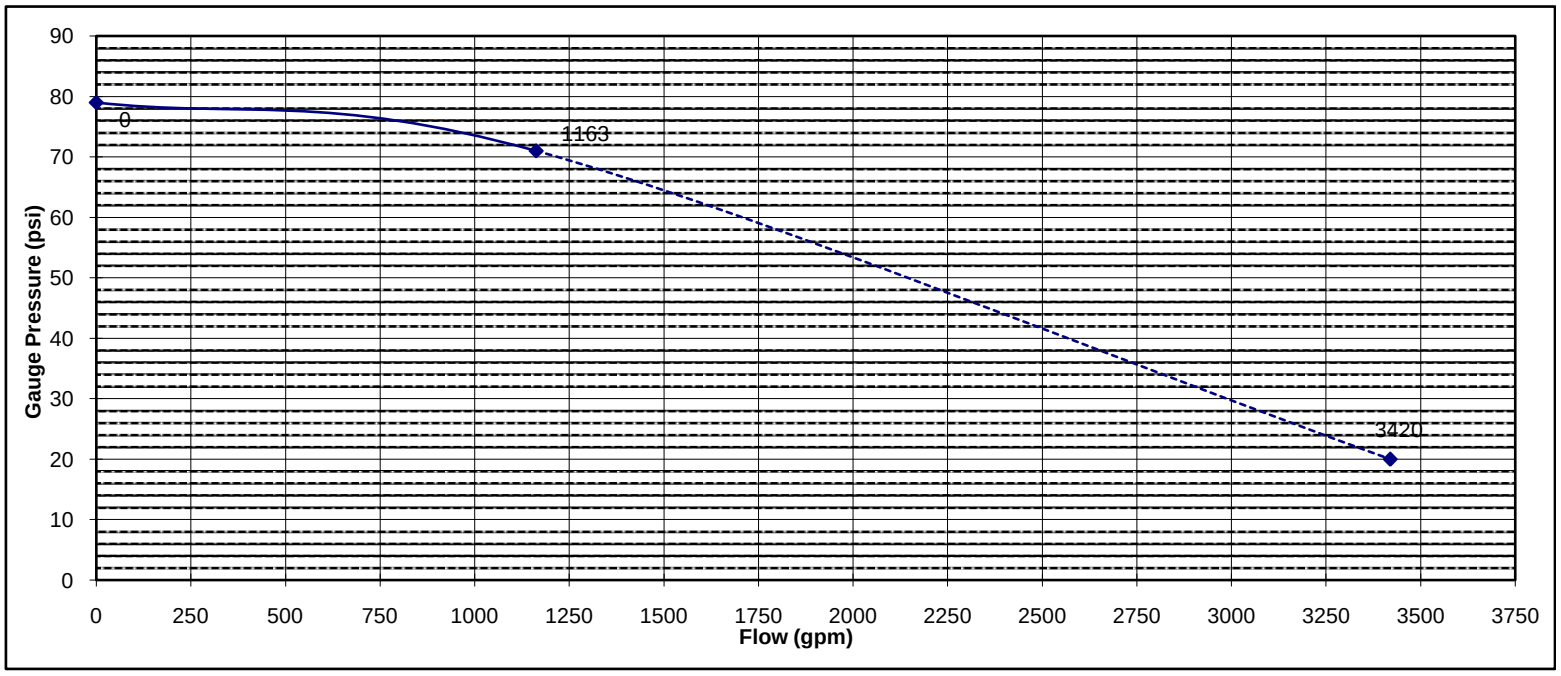
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	79	psi @	0	gpm
Residual pressure of	71	psi @	1162.5	gpm
Available flow @	20	psi --	3419.7	gpm

Flow at 20 psi: 3419.7 gpm



Comments:

NOTES:

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2. Flow analysis assumes a gravity flow system with no distribution pumps and having no demand, other than the test
3. The distance between hydrants, elevations & main diameters are for information only.

WESTERN STATES FIRE PROTECTION CO.
2026 West Lone Cactus Drive
Phoenix, AZ 85027
Phone (602) 272-2200
Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-12 / WTFH3N1WSE170006 / W. CACTUS & 2 BLKS E. OF 151AVE

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 64

Pitot Reading: 50.00

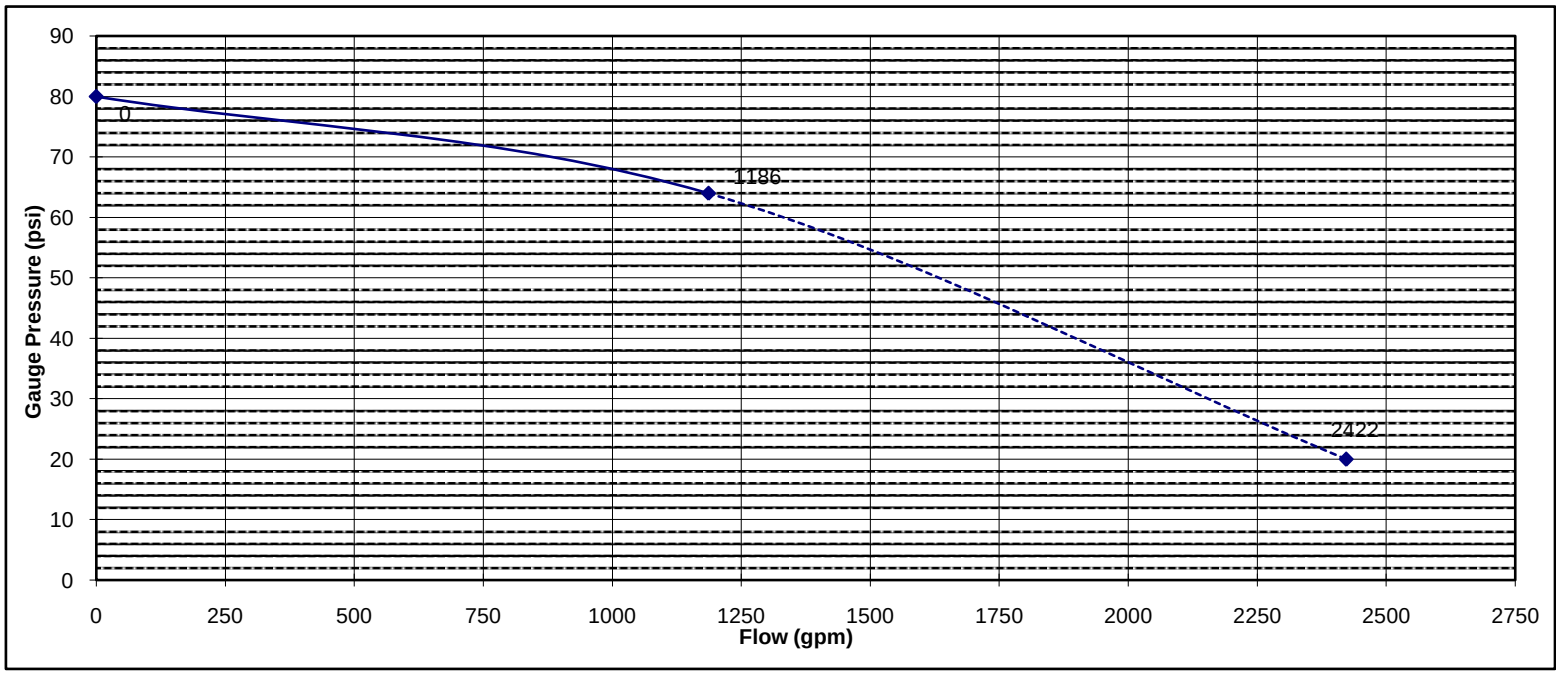
Flow: 1186.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	64	psi @	1186.5	gpm
Available flow @	20	psi --	2422.4	gpm

Flow at 20 psi: 2422.4 gpm



Comments:

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DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 80.00

Residual Pressure: 62

Pitot Reading: 48.00

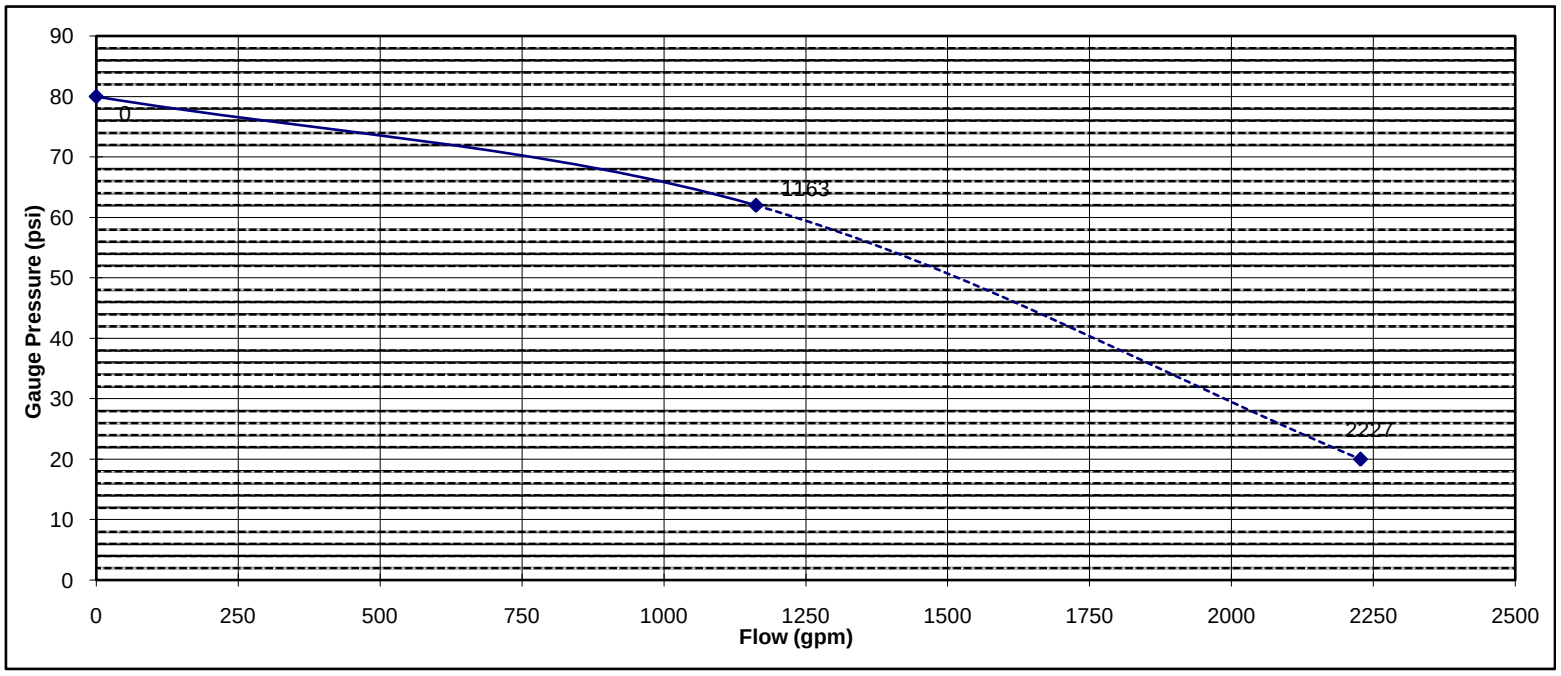
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	80	psi @	0	gpm
Residual pressure of	62	psi @	1162.5	gpm
Available flow @	20	psi --	2227.2	gpm

Flow at 20 psi: 2227.2 gpm



Comments:

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4646 E. Van Buren St. Suite #400
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FF-13 / WTFH3N1WSE200002 / W. GABRIELA, S. 151 LN & BECKER

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 75

Pitot Reading: 62.00

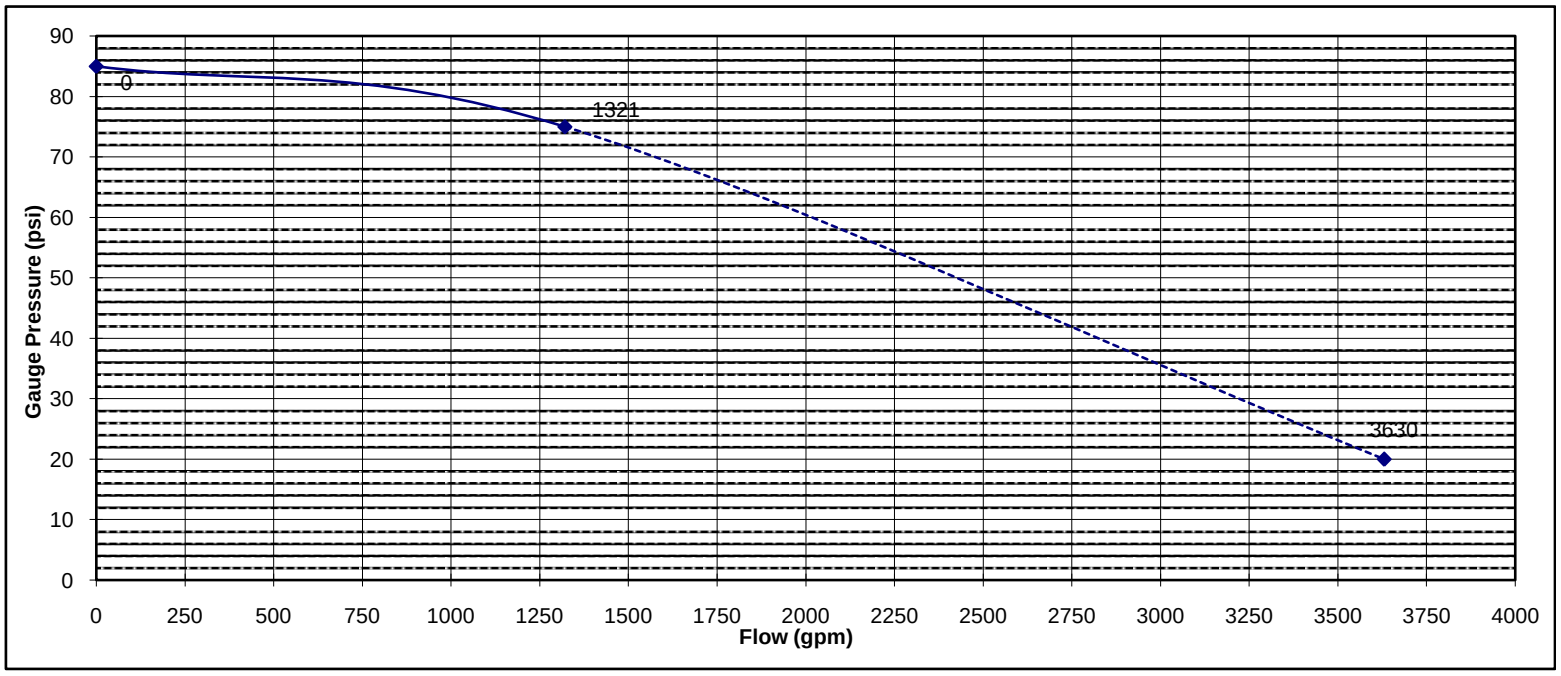
Flow: 1321.2 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	75	psi @	1321.2	gpm
Available flow @	20	psi --	3630.3	gpm

Flow at 20 psi: 3630.3 gpm



Comments:

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DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 84.00

Residual Pressure: 64

Pitot Reading: 57.00

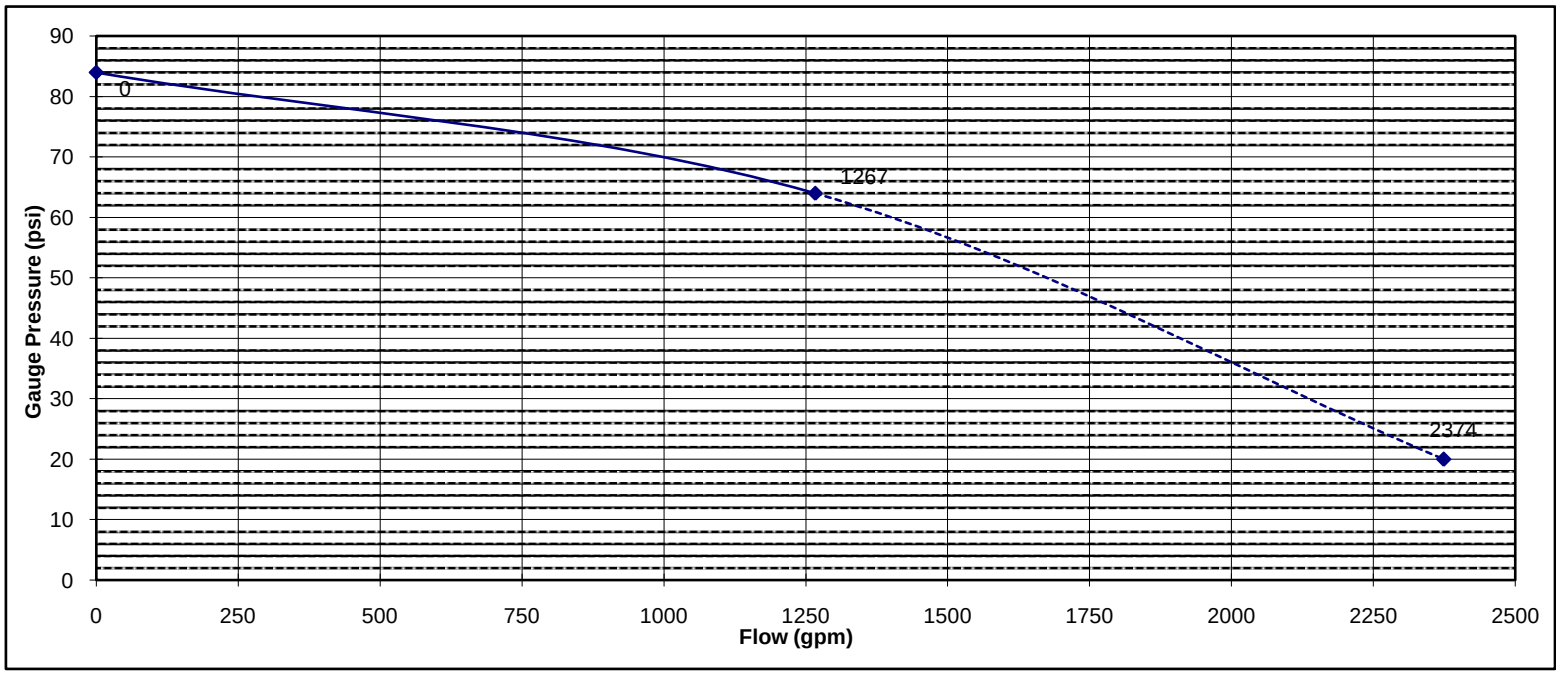
Flow: 1266.8 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	84	psi @	0	gpm
Residual pressure of	64	psi @	1266.8	gpm
Available flow @	20	psi --	2374.1	gpm

Flow at 20 psi: 2374.1 gpm



Comments:

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DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 86.00

Residual Pressure: 70

Pitot Reading: 58.00

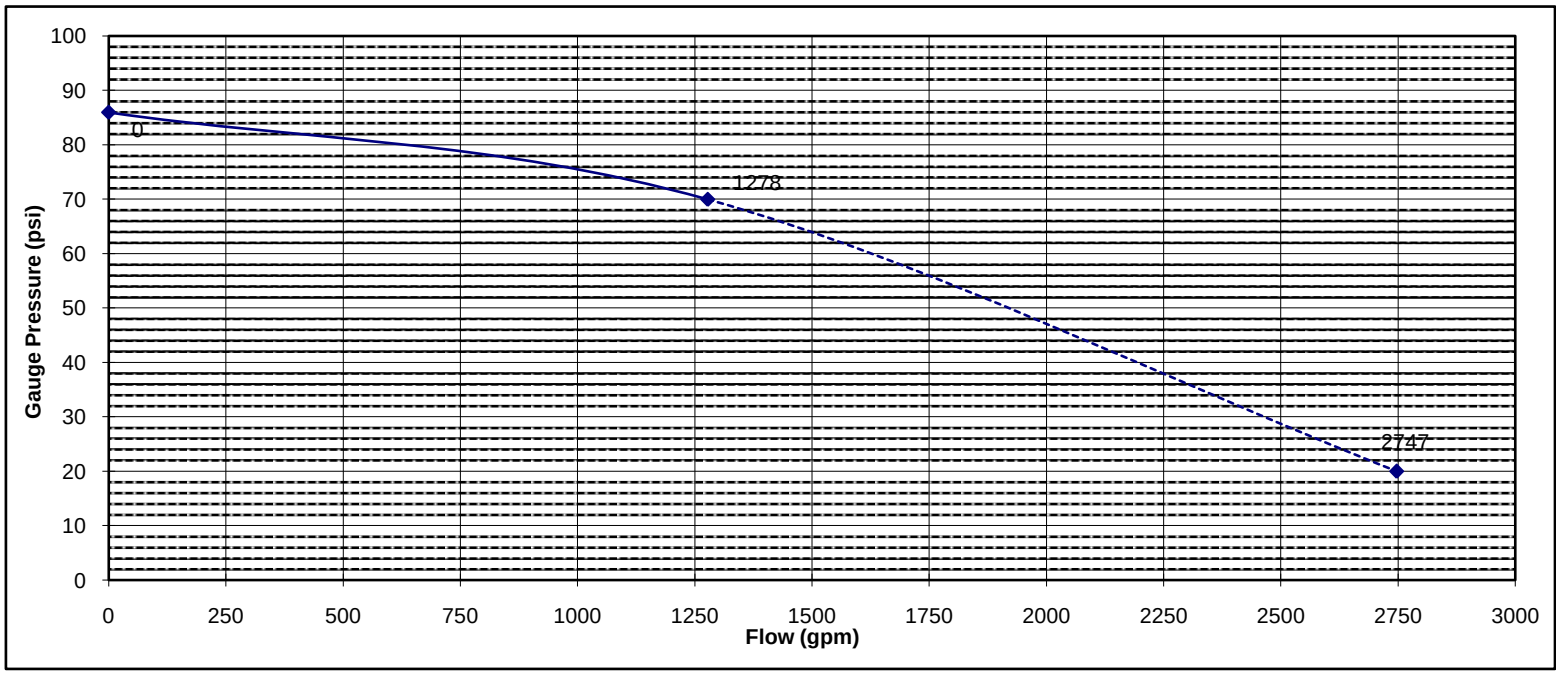
Flow: 1277.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	86	psi @	0	gpm
Residual pressure of	70	psi @	1277.9	gpm
Available flow @	20	psi --	2746.7	gpm

Flow at 20 psi: 2746.7 gpm



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LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 72.00

Residual Pressure: 49

Pitot Reading: 47.00

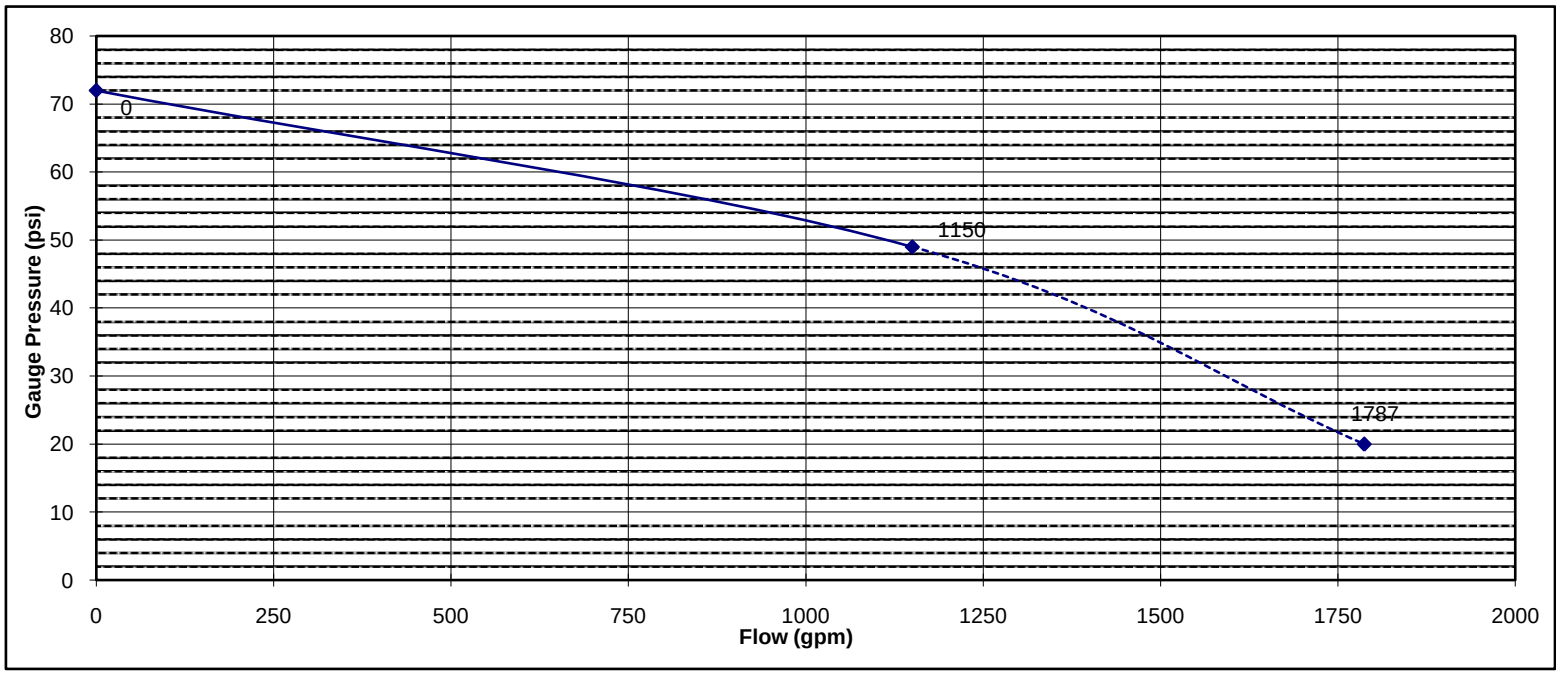
Flow: 1150.3 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	72	psi @	0	gpm
Residual pressure of	49	psi @	1150.3	gpm
Available flow @	20	psi --	1787.0	gpm

Flow at 20 psi: 1787.0 gpm



Comments:

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Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 76.00

Residual Pressure: 56

Pitot Reading: 48.00

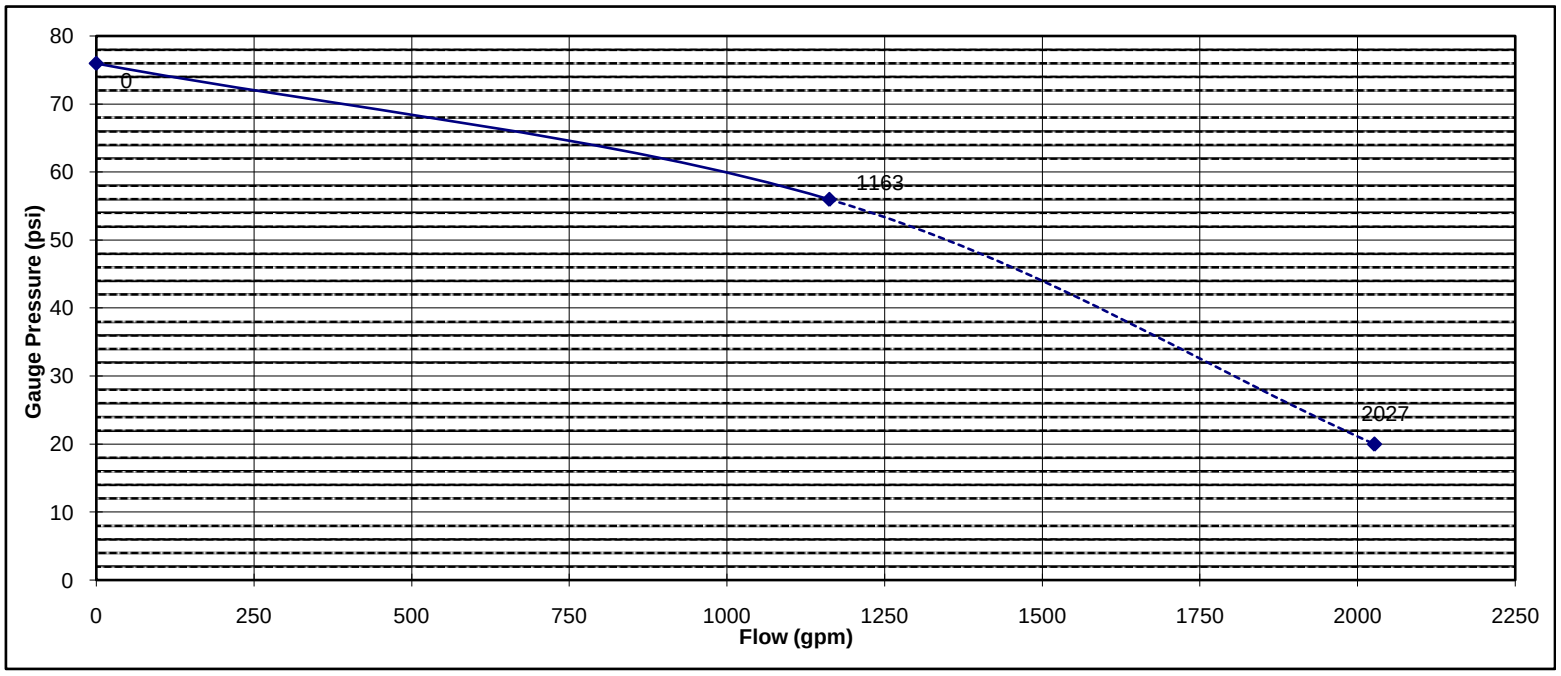
Flow: 1162.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	76	psi @	0	gpm
Residual pressure of	56	psi @	1162.5	gpm
Available flow @	20	psi --	2027.0	gpm

Flow at 20 psi: 2027.0 gpm



Comments:

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Phoenix, AZ 85027
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Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-14 / WTFH3N1WNW100020 / NWC OF ACAPULCO & 137TH

DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 75.00

Residual Pressure: 62

Pitot Reading: 50.00

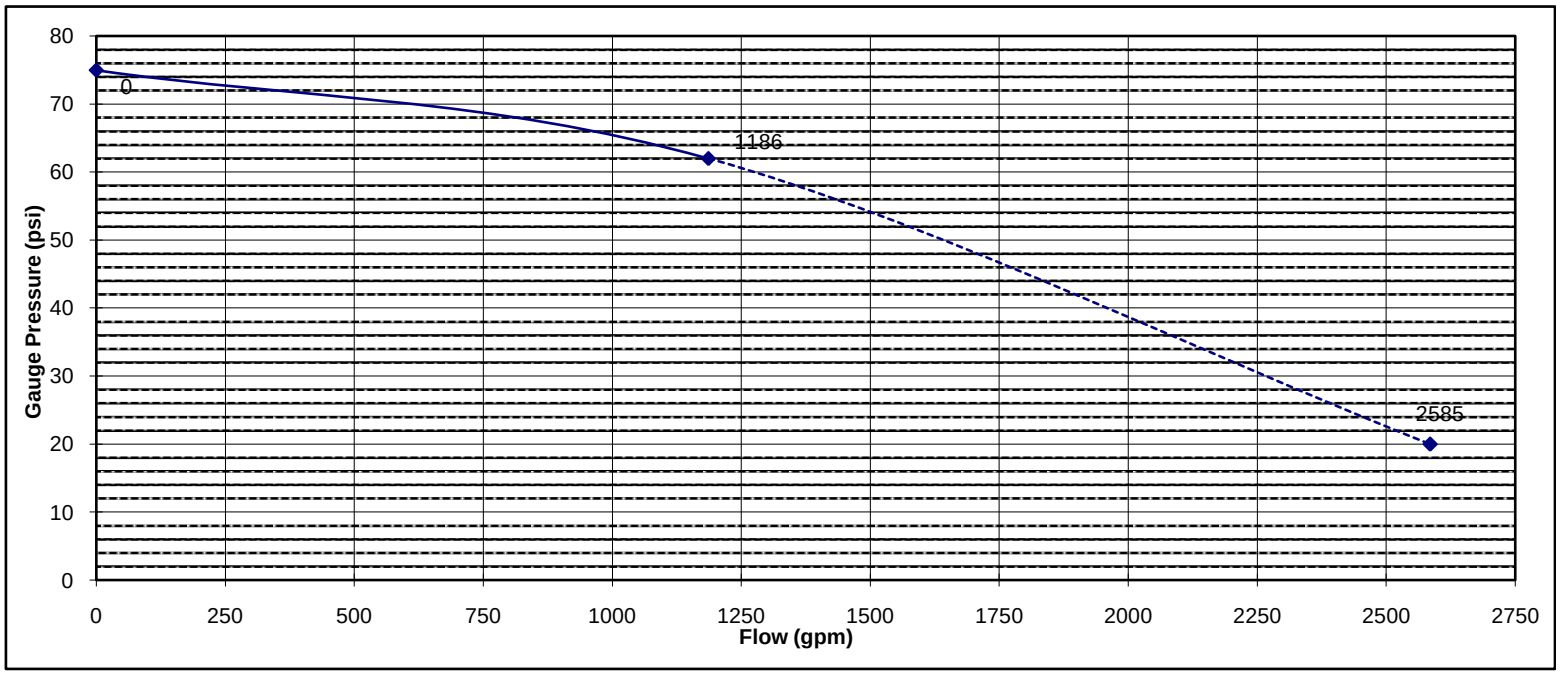
Flow: 1186.5 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	75	psi @	0	gpm
Residual pressure of	62	psi @	1186.5	gpm
Available flow @	20	psi --	2585.4	gpm

Flow at 20 psi: 2585.4 gpm



Comments:

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WESTERN STATES FIRE PROTECTION CO.

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Phoenix, AZ 85027
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Fax (602) 272-7972

LOCATION **Malcolm Pirnie, Inc.**
4646 E. Van Buren St. Suite #400
Phoenix, Az. 85008-6945
FF-15 / WTFH3N1WSE090052 / WADDELL RD & 140TH, NEC

DATE: 06/09/08
TIME: 7:30AM
Report# 1
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1
Coeff. of Discharge: 0.90

Static Pressure: 85.00

Residual Pressure: 70

Pitot Reading: 62.00

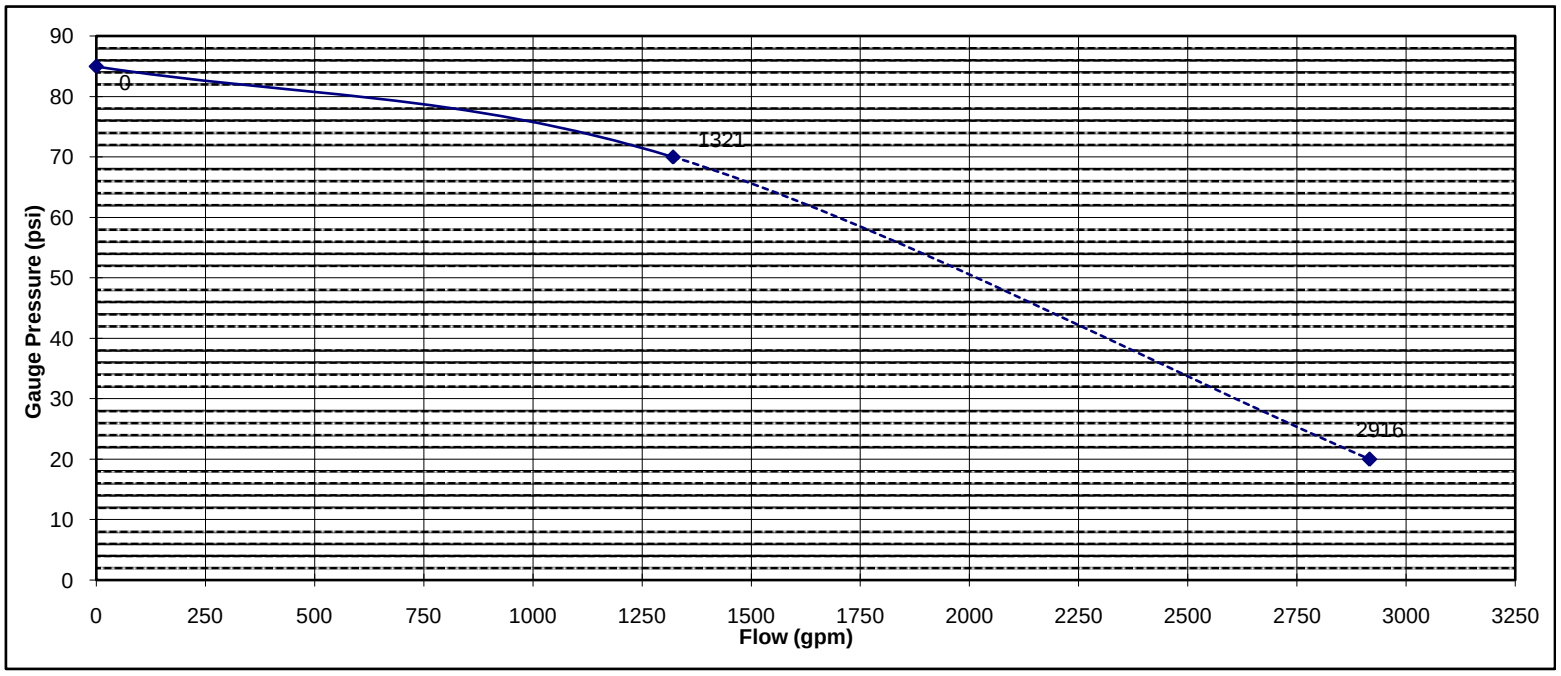
Flow: 1321.2 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	85	psi @	0	gpm
Residual pressure of	70	psi @	1321.2	gpm
Available flow @	20	psi --	2916.5	gpm

Flow at 20 psi: 2916.5 gpm



Comments:

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FF-15 / WTFH3N1WSE090052 / WADDELL RD & 140TH, NEC

DATE: 06/09/08
TIME: 12:00PM
Report# 2
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 76

Pitot Reading: 70.00

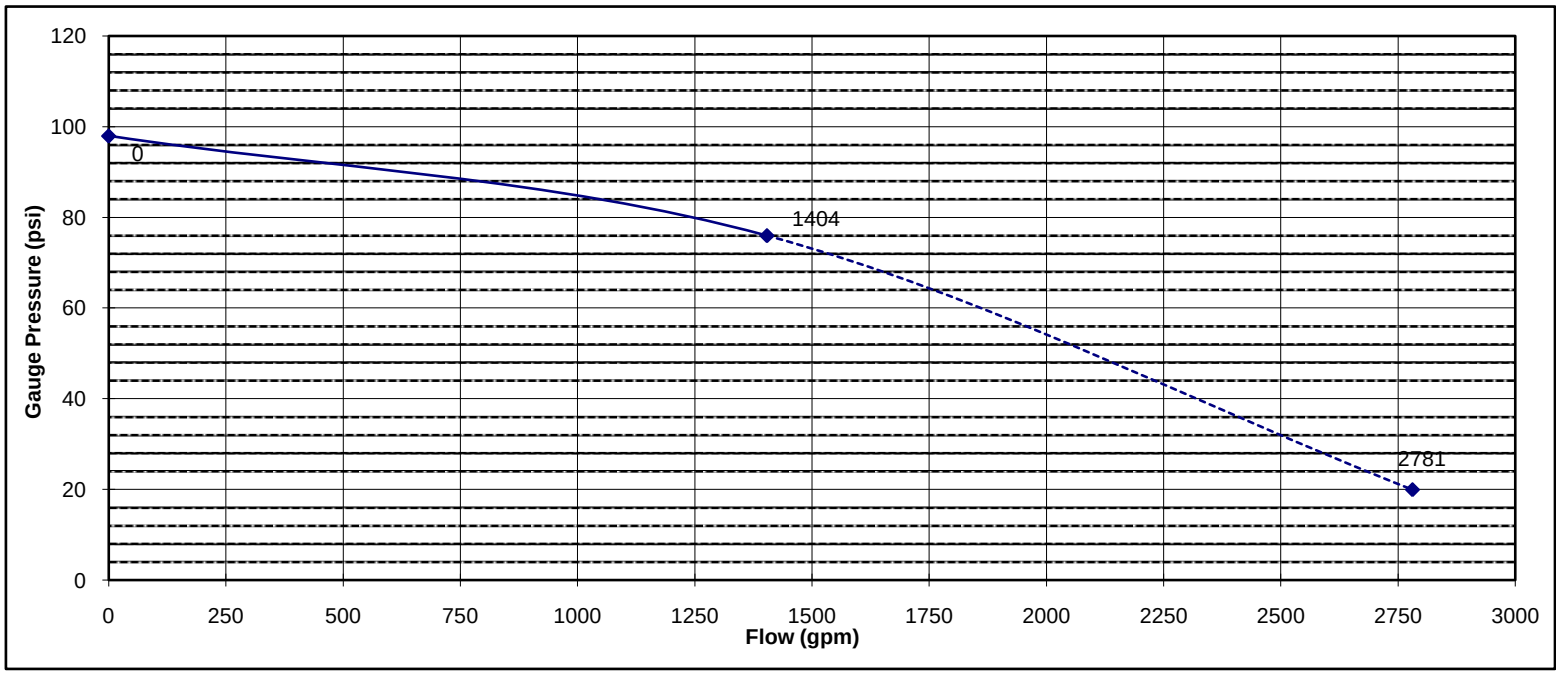
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	76	psi @	1403.9	gpm
Available flow @	20	psi --	2780.7	gpm

Flow at 20 psi: 2780.7 gpm



Comments:

NOTES:

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DATE: 06/09/08
TIME: 3:00PM
Report# 3
Tech: PK / BW

Static Hydrant Number:
Elevation: 0

Flowing Hydrant Number:
Elevation: 0

Dist. Between Hydrants: 300'

Diameter of Main: 8"

Type of Supply: CITY WATER

Outlet Diameter: 2.5

Number flowing: 1

Coeff. of Discharge: 0.90

Static Pressure: 98.00

Residual Pressure: 79

Pitot Reading: 70.00

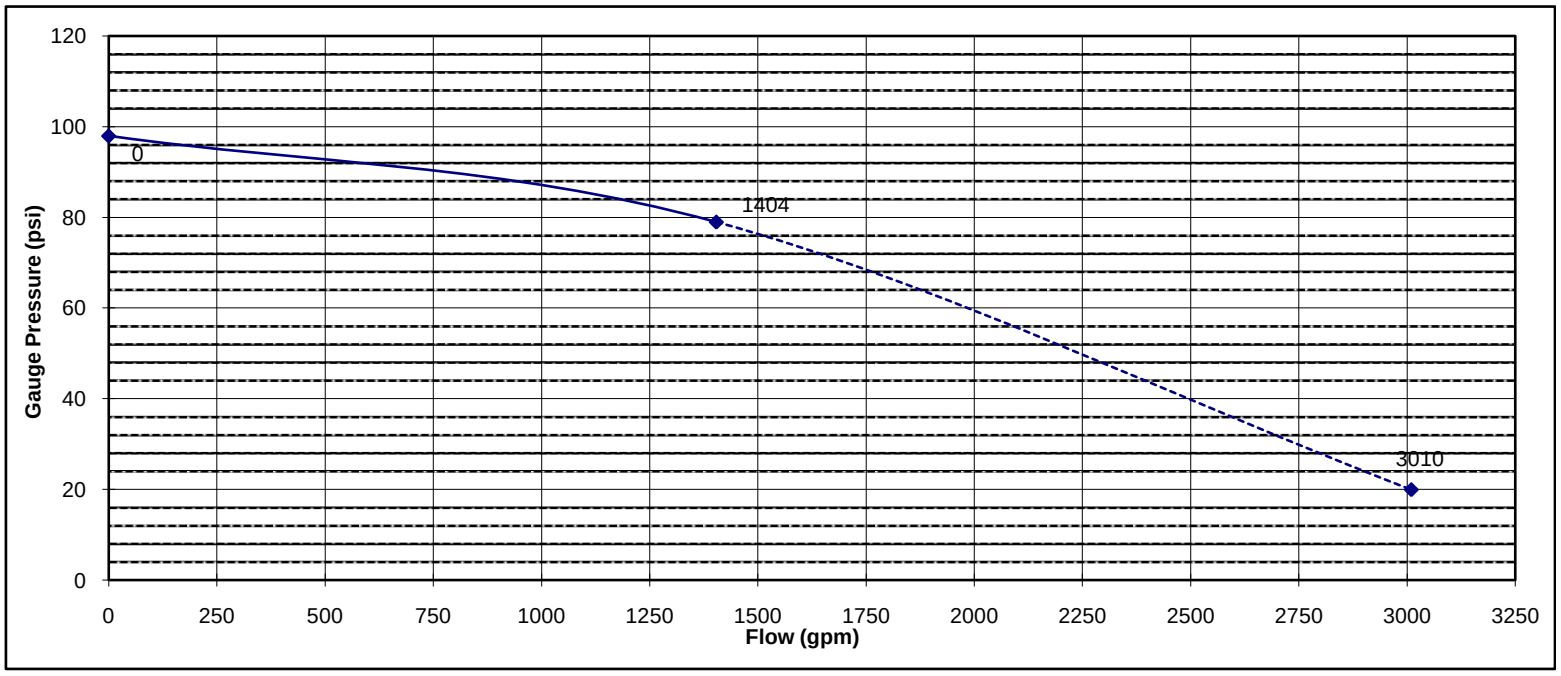
Flow: 1403.9 gpm

Pump Present: N/A

Tank Present: N/A

Static pressure of	98	psi @	0	gpm
Residual pressure of	79	psi @	1403.9	gpm
Available flow @	20	psi --	3009.7	gpm

Flow at 20 psi: 3009.7 gpm



Comments:

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3. The distance between hydrants, elevations & main diameters are for information only.

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C. Wastewater System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 5.3 – Wastewater Collection System Monitoring
- Task 5.4 – Flow Model

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City of Surprise, Arizona
Water Services Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Wastewater Technical Memorandum:

Task 5.3 – Wastewater Collection System Monitoring
Task 5.4 – Flow Model

November 2008

Report Prepared By:

Malcolm Pirnie, Inc.

4646 East Van Buren Street
Suite 400
Phoenix, AZ 85008

4957-006

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A. Flow Monitoring Test Results

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1. Introduction

1.1. Background

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also

includes updates to projections of wastewater flows, reclaimed water availability, and reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

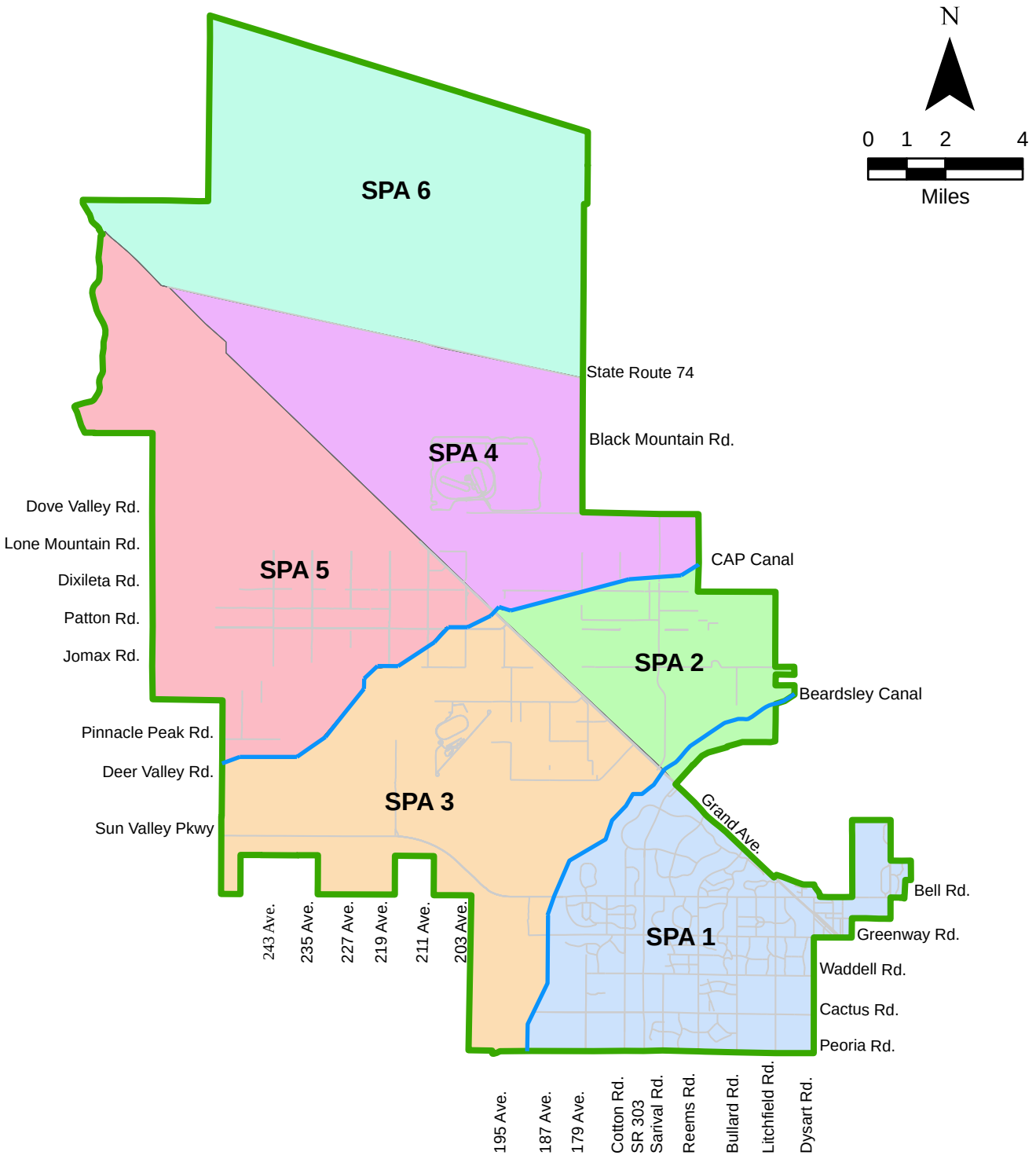
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
	5.7 Wastewater Master Plan Report
Recharge Master Plan	**Reclaimed Water Master Plan**
3.1 Regulations and Background Information	6.1 Review of Background Information
3.2 Recharge Methods and Evaluation	6.2 Flow Model
3.3 Recharge Improvements	6.3 Evaluation of the Existing System
3.4 Build-out of the Recharge System	6.4 Improvements to the Existing System
3.5 Recharge Master Plan Report	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Wastewater Master Plan Tasks 5.3 (Wastewater Collection System Monitoring) and 5.4 (Flow Model). The technical memorandum includes descriptions of how the wastewater collection system model was developed, the collection system monitoring that was conducted, and the process used to calibrate the model using the collection system monitoring results. In future tasks, the calibrated model will be used to evaluate the existing system and future scenarios to determine necessary wastewater infrastructure improvements.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's MPA. The MPA has been divided into six SPAs to maintain consistency with the City's previous master plan efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Streets
- Canals
- Municipal Planning Area
- Special Planning Areas

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INTEGRATED WATER MASTER PLAN

Study Area

November 2008

Figure 1-1

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2. Model Development

A computerized hydraulic model was developed to simulate the response of the City's wastewater collection and conveyance system to wastewater flow generation scenarios. The model was used to identify the adequacy of the system to accommodate existing and projected wastewater flows within the existing service area and to identify future system improvements as the service area develops. This section describes the development of the City's existing wastewater collection system model.

2.1. Data Sources

The primary sources of information for the current modeling effort were the most current geographical information system (GIS) shapefiles provided by the City and the existing collection system model last updated in 2004. Supplemental information for the model was collected during field visits conducted in May 2008 and through interviews with City staff. Collection system spatial loadings were obtained from the Water Resource Demand Module (Demand Module) developed as a part of *Water Resources Master Plan.*

2.2. Model Description

As indicated in the previous master planning efforts, collection system flows within the City's wastewater planning areas were divided into SPAs. Because a majority of existing developments lie in SPA 1, the existing system model updated was limited to SPA 1. The City did not have an existing wastewater model for new developments within the other area that is partially developed, SPA 2. Models for SPA 2 and other the remaining SPAs will be developed and evaluation as part of subsequent tasks in the Wastewater Master Plan.

The City's existing collection system was modeled using SewerCAD®, version 5.6. SewerCAD® is a commercially available program for the design and analysis of gravity flow and pressure flow through pipe networks and pumping stations. The gravity network is calculated using a built-in numerical model, which utilizes both the direct step and standard step, gradually varied flow methods. Gravity and pressure flow components can also be modeled, with the systems in parallel or in series as they exist in the field. Pressure flow elements can be controlled based on system hydraulics, with pumps turned on or off based on changes in flows and pressures.

SewerCAD® can run both steady state and extended period analyses. Steady state analyses model a single instant in time and are generally used to model a network under

peak loading conditions (maximum or minimum) and average loading conditions. Extended period analyses model a network over a specified duration of time and are generally used to model hydrograph loading, wet well capacities, and automated pump behavior. For the purposes of this master planning effort, the City's wastewater collection/conveyance system was modeled using steady state analyses.

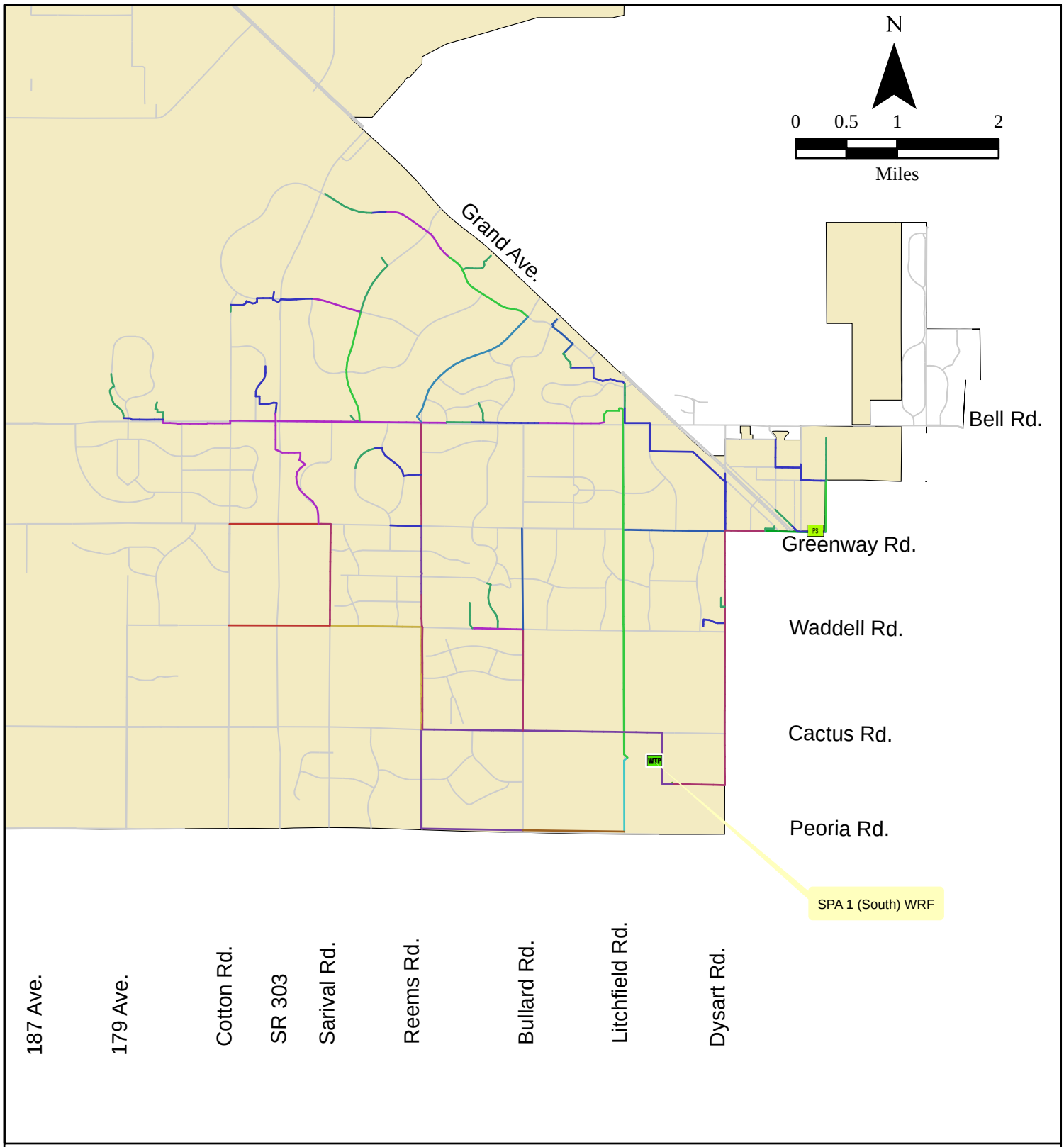
The City's existing system consists of nearly 3 million feet of pipe (gravity and force mains), roughly 11,250 manholes, and 7 pump stations. Because not all pipelines are necessary to adequately model the collection system, a skeletonized network of pipes was represented in the existing model provided by the City. Skeletonization is typically performed using standard modeling procedures to remove pipes that do not change or affect the hydraulics of the system. Starting with the existing model provided by the City, a similar methodology was used to update the model to existing (2008) conditions (Figure 2-1). A comparison of the modeled system versus the entire collection system (as measured from the City's GIS database) is shown in Table 2-1. The percentage of the existing wastewater infrastructure shown in Table 2-1 that is being modeled is typical for master planning.

Table 2-1.
Modeled and System Attribute Summary

System Attribute	Modeled	System Total	Percent of System Modeled
Manholes	553	11,250	4.9%
Gravity Sewers (feet)	202,000	2,903,299	7.0%
Force Mains (feet)	2,619	60,385	4.3%
Pump Stations	2	7	28.6%

2.3. Flow Allocation

Once the physical structures of the model were developed (pipe, manholes, pump stations, etc.), wastewater loadings were imported into the model. The system loadings were located spatially using the Demand Module. The Demand Module utilizes City land use categories, service areas, dwelling unit densities, and water demand factors (gallons per day per acre or per dwelling unit) to project water demands and wastewater flows. The Demand Module assumes that 100 percent of indoor water consumption is returned to the City via the wastewater collection system (wastewater loading). These demands and flows are spatially allocated throughout the City and can be isolated by water service provider, or in this case, wastewater service provider. The flows used in the model calibration were limited to SPA 1 and the City's wastewater service area.



Legend

- Streets
- City of Surprise Wastewater Service Area
- Lift Stations
- Water Reclaimation Facility
- Force Main

Gravity Pipe

- 6 inch
- 8 inch
- 10 inch
- 12 inch
- 15 inch
- 18 inch
- 21 inch
- 24 inch
- 27 inch
- 30 inch
- 42 inch
- 48 inch
- 54 inch

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Modeled Collection System (Skeletonized)

November 2008 | **Figure 2-1**

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3. Model Calibration

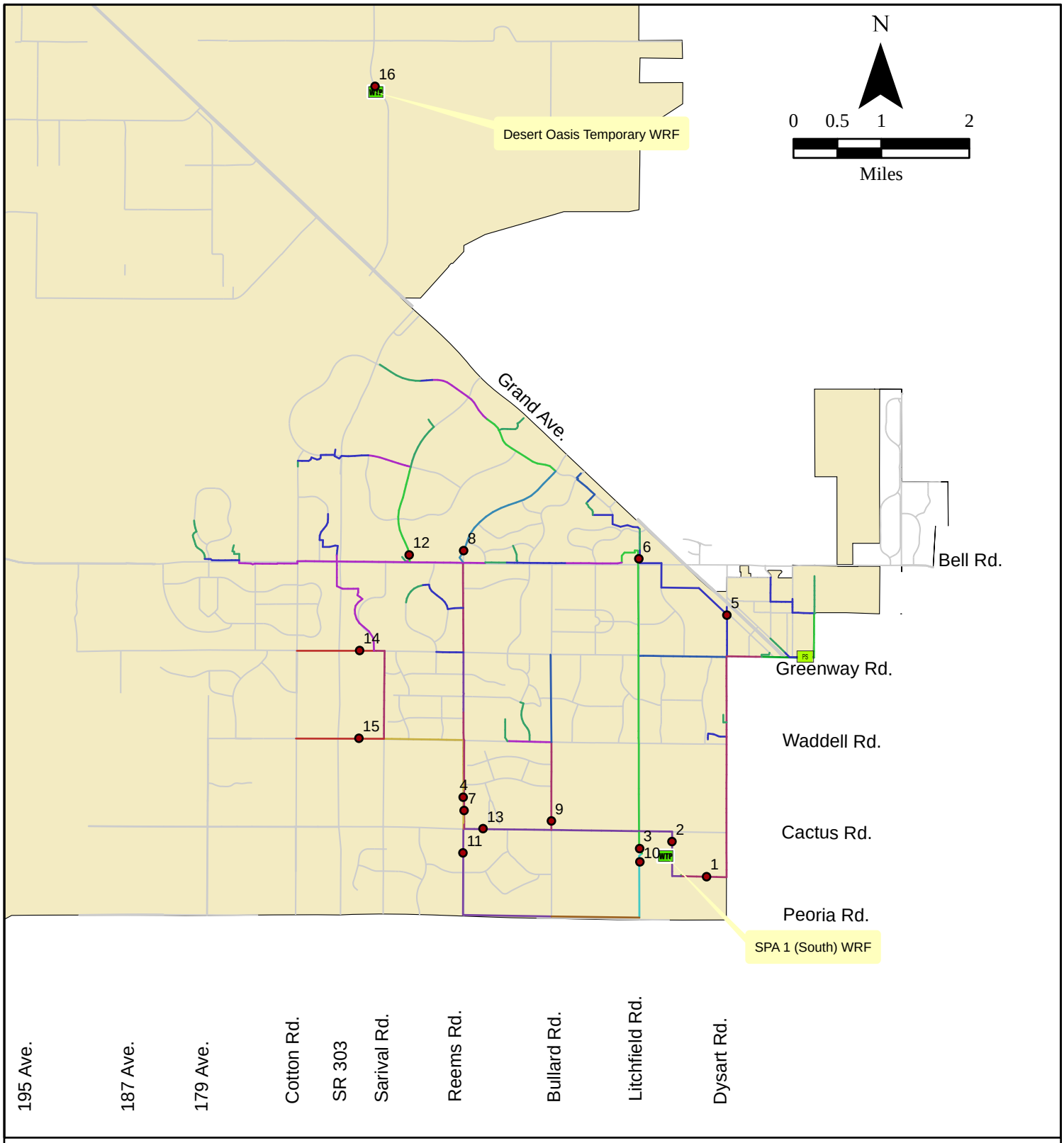
This section describes how the City's existing wastewater collection system was calibrated. Model calibration is necessary before conducting a system analysis to ensure that the model setup represents the actual system with sufficient accuracy. The level of calibration depends on the intended use of the model. The model developed for this project will be a steady-state model with primary use as a master planning tool. Flow and depth data gathered from the collection system monitoring performed in June 2008 were used to calibrate the model.

3.1. Collection System Monitoring

Collection system flow monitoring was conducted to determine the flow, depth, and velocity at key locations throughout the City's collection system (Figure 3-1). The parameters were recorded in 15 minute intervals for a two week period starting on June 12, 2008 and ending on June 25, 2008. Half way through the testing, meter calibration was verified. With the exception of flow meter #5 which captures commercial area flows, the remaining flow meters collected data from residential areas as defined in the City's General Plan. Flow meter #16 was located in SPA 2 to capture data that may be used for future evaluations.

The average, maximum, and minimum values for the flow, depth, and velocity for each flow meter is presented in Table 3-1. The typical hydrograph pattern observed during the testing indicates elevated flows during the weekends, characteristic of bedroom communities where people commute to nearby cities during the work week (Figure 3-2). The maximum hour weekend flow conditions observed during the testing were assessed in the model. The complete set of flow monitoring data is presented in Appendix A.

During the data collection process, it was noted that flow meter #10 was heavily influenced by a nearby pump station, which may have caused some excessive peak flows associated with the pump station's operation. It should also be noted that the meter located in the commercial area (#5) had a different flow pattern than the rest of the meter locations. Its hydrograph exhibited a single peak during business hours as opposed to the diurnal peak normally associated with residential areas. The average flow from flow meter #2 (receiving water from metered basin #9 and #13), was lower than the sum of the flows from flow meters #9 and #13. Review of the flow meter data did not reveal any explanation for this discrepancy and as a result, the data from flow meters #9 and #13 were used instead.



Legend

- Streets
- City of Surprise Wastewater Service Area
- Flow Monitoring Locations
- Lift Stations
- Water Reclaimation Facility
- Force Main

Gravity Pipe

- 6 inch
- 8 inch
- 10 inch
- 12 inch
- 15 inch
- 18 inch
- 21 inch
- 24 inch
- 27 inch
- 30 inch
- 42 inch
- 48 inch
- 54 inch

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Flow Monitoring Locations

November 2008

Figure 3-1

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Table 3-1.
Flow Meter Summary

Meter ID	Flow (mgd)			Depth (in)			Velocity (ft/s)		
	Avg	Max	Min	Avg	Max	Min	Avg	Max	Min
1	1.13	1.90	0.45	6.71	8.46	4.42	2.37	3.04	1.67
2	2.09	4.13	0.63	4.45	6.76	2.26	6.83	7.92	5.75
3	0.97	1.74	0.31	4.81	6.54	2.74	2.84	3.47	1.93
4	1.39	2.28	0.55	4.41	5.41	3.69	4.96	6.29	2.57
5	0.14	0.29	0.05	2.52	3.69	1.47	1.72	2.30	1.23
6	0.39	0.64	0.15	4.00	5.10	2.65	1.71	2.15	1.11
7	1.41	2.91	0.56	4.47	6.70	2.89	5.23	6.46	3.95
8	0.20	0.60	0.06	2.70	4.66	1.54	1.64	2.36	1.02
9	0.54	1.27	0.15	4.35	6.87	2.38	2.05	2.64	1.38
10	1.43	4.93	0.44	12.90	37.59	5.14	1.07	1.86	0.17
11	1.11	2.00	0.47	3.79	5.27	2.72	5.03	6.04	3.54
12	0.25	0.73	0.05	1.94	3.24	1.25	3.46	5.30	1.34
13	1.80	3.62	0.57	5.30	7.57	3.78	4.59	5.81	2.39
14	0.49	0.87	0.14	5.73	7.46	3.72	1.50	2.09	0.69
15	0.30	0.62	0.06	4.13	6.81	1.88	1.45	2.12	0.88
16	0.11	0.21	0.03	1.60	2.12	1.09	1.78	2.51	0.90

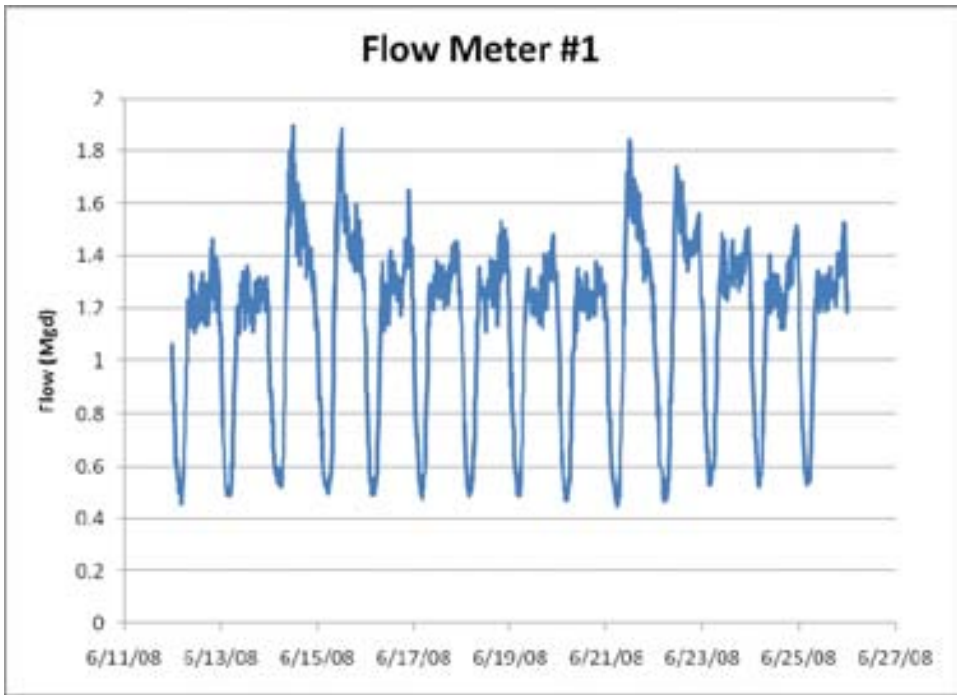

Figure 3-2: Example Hydrograph from Collection System Monitoring

3.2. Model Calibration

In order to obtain an accurate representation of the collection system, the model results were reviewed against the metered values and City staff operational knowledge. Model parameters listed below were adjusted to meet reasonable calibration goals, as well as the City's understanding of the system.

- Average wastewater loads quantity
- Spatial location of wastewater loads
- Peaking factors
- Pipe roughness
- Collection system configuration
- Pipe constrictions/obstructions

Table 3-2 summarizes the peaking factors used for each of the flow meter basins. The peaking factors used were based on the flow meter results for each basin with two exceptions. Flow meter basins #2 and #10 were based on an area weighted average of the remaining basin's peaking factors. These two basins were impacted by a flow imbalance or were influenced by a downstream pumping station, which made direct use of the meter results to determine the peaking factor difficult. As there were no precipitation events during the monitoring program, the values listed in Table 3-2 could be viewed as dry weather peaking factors experienced during the monitoring program.

Table 3-2.
Flow Meter Peaking Factors

Meter ID	Peaking Factor
1	1.66
2	2.05
3	2.02
4	1.14
5	2.03
6	1.64
7	1.92
8	2.94
9	2.34
10	2.05
12	2.95
14	1.78
15	2.09

3.2.1. Calibration Guidelines

The ranges listed below were used as guidelines during the calibration process. In the event that these ranges could not be achieved, possible explanations for the variance were explored.

- The average modeled flow is ± 10 percent of the metered average flow
- The peak hour modeled flow is ± 10 percent of the metered peak hour flow
- The peak hour modeled flow depth is ± 4 inches of the metered peak hour flow depth

3.2.2. Model Results vs. Meter Records

The average flow during the monitoring period influent to the treatment plant was determined by analyzing the data from flow meters #1, #2, #3, and #10 to yield an average flow rate of 5.62 mgd. The average annual flow rate as determined from the Demand Module was 5.86 mgd. Tables 3-3, 3-4 and 3-5 show the comparison of the model results for average flow, peak hour flow, and depth at peak hour conditions along with the relative percentage difference and whether or not the calibration goal was met. A composite summary of the calibration goals is presented in Table 3-6.

Table 3-3.
Calibration Comparison for Average Flow Conditions

Flow Meter	Meter Flow Rate (mgd)	Model Flow Rate (mgd)	Percent Difference (%)	Calibration Goal Met?
1	1.13	1.12	-0.7%	Yes
2	2.09	2.22	6.0%	Yes
3	0.97	0.97	-0.3%	Yes
4	1.39	1.48	6.4%	Yes
5	0.14	0.13	-4.1%	Yes
6	0.39	0.37	-5.9%	Yes
7	1.41	1.33	-5.9%	Yes
8	0.20	0.20	-3.7%	Yes
9	0.54	0.54	-0.6%	Yes
10	1.43	1.54	8.0%	Yes
11	1.11	1.18	6.6%	Yes
12	0.25	0.25	1.3%	Yes
13	1.80	1.62	-9.9%	Yes
14	0.49	0.49	0.3%	Yes
15	0.30	0.30	0.7%	Yes

Table 3-4.
Calibration Comparison for Peak Flow Conditions

Flow Meter	Meter Flow Rate (mgd)	Model Flow Rate (mgd)	Percent Difference (%)	Calibration Goal Met?
1	1.90	1.91	0.8%	Yes
2	4.13	4.84	17.1%	No
3	1.74	1.82	4.5%	Yes
4	2.28	2.28	0.3%	Yes
5	0.29	0.27	-5.2%	Yes
6	0.64	0.65	1.1%	Yes
7	2.91	3.01	3.3%	Yes
8	0.60	0.58	-2.5%	Yes
9	1.27	1.26	-0.8%	Yes
10	4.93	2.56	-48%	No
11	2.00	1.83	8.9%	Yes
12	0.73	0.74	1.4%	Yes
13	3.62	3.47	-4.4%	Yes
14	0.87	0.87	0.3%	Yes
15	0.62	0.63	0.6%	Yes

Table 3-5.
Calibration Comparison for Depth at Peak Flow Conditions

Flow Meter	Meter Depth at Peak Hour (in)	Model Depth at Peak Hour (in)	Difference (in)	Calibration Goal Met?
1	8.46	9.36	-0.9	Yes
2	6.76	12.60	-6.20	No
3	6.54	8.04	-1.50	Yes
4	5.41	9.00	-3.59	Yes
5	3.69	3.36	0.33	Yes
6	5.10	5.04	0.05	Yes
7	6.70	9.12	-2.42	Yes
8	4.66	7.68	-3.02	Yes
9	6.87	7.92	-1.06	Yes
10	37.59	8.40	29.19	No
11	5.27	6.60	-1.33	Yes
12	3.24	6.36	-3.13	Yes
13	7.57	10.80	-3.23	Yes
14	7.46	7.32	0.14	Yes
15	6.81	9.36	-2.55	Yes

Table 3-6.
Summary of Calibration Results

Flow Meter	Average Flow Rate	Peak Hour Flow Rate	Depth at Peak Hour	Calibrated?
1	Yes	Yes	Yes	Yes
2	Yes	No	No	Partially
3	Yes	Yes	Yes	Yes
4	Yes	Yes	Yes	Yes
5	Yes	Yes	Yes	Yes
6	Yes	Yes	Yes	Yes
7	Yes	Yes	Yes	Yes
8	Yes	Yes	Yes	Yes
9	Yes	Yes	Yes	Yes
10	Yes	No	No	Partially
11	Yes	Yes	Yes	Yes
12	Yes	Yes	Yes	Yes
13	Yes	Yes	Yes	Yes
14	Yes	Yes	Yes	Yes
15	Yes	Yes	Yes	Yes

For average flow conditions, the calibration goals were met at all the flow meter locations. The relative percentage differences in flows were within the accepted range. Therefore, the model was successfully calibrated for the average flow conditions.

For peak hour flow conditions, flow meters #2 and #10 did not meet the calibration goal. For flow meter # 2, the sum of the flows recorded at the two upstream flow meters (#9 and #13) was higher than the reading at meter #2. This is most likely due to an incorrect understanding of the piping configuration upstream of meter #2. For this reason, peak hour calibration at this meter was not possible. Flow meter #10 exhibited flow spikes that were difficult to match in a steady-state model. These spikes were likely due to the downstream pump station. For this reason, the peak hour calibration goal could not be met at this location either.

For depth at peak hour flow conditions, flow meters #2 and #10 did not meet the calibration goals. Since flow meters #2 and # 10 did not meet the peak hour calibration goals, the peak hour flow depth calibration goal, likewise, could not be met.

Even though the other flow meters met the calibration goals, some flow meters (#4, #12, #13, #14 and #15) raised concerns because they were located within smaller diameter sewers. As the diameter of the collection system pipe decreases, a 3-inch difference in the metered versus modeled flow depths becomes a greater percentage of the pipe's

diameter. To minimize the difference between the model and metered depths, the pipe roughness was adjusted in the vicinity of the flow meter basins.

3.3. Calibration Results

Based on the comparison of the metered versus modeled results for three calibration goals, the City's model was considered calibrated for the existing conditions. The accuracy of the model was considered sufficient to perform system-wide evaluations for master planning purposes, including responses to stress conditions such as peak hour flow during dry and wet weather conditions.

A. Flow Monitoring Test Results

CITY OF SURPRISE, AZ MASTER PLAN

PREPARED FOR: MALCOLM PIRNIE, INC. – TIMOTHY FRANCIS, P.E., BCEE

PREPARED BY: INFRASTRUCTURE ENGINEERING CORP. – CYNTHIA JORDAN-KASPER

DATE: JULY 16, 2008

UPTIME: 100%

USEABLE DATA: 100%

1.0 Project Summary

The purpose of this report is to present the results of a comprehensive wastewater flow monitoring project conducted by Infrastructure Engineering Corporation (IEC) for Malcolm Pirnie, Inc. The flow monitoring project was carried out to establish the capacity sewage flows at sixteen (16) locations in the City of Surprise sanitary sewer system. The objective of the project was to provide information to Malcolm Pirnie, Inc. for the preparation of a Wastewater Master Plan for the City of Surprise and its environs.

The flow survey was carried out from 06/09/08 through 06/27/08. The data contained in this report is for the period of 06/12/08 beginning at 00:00 AM through 06/25/08 ending at 23:45 PM. The result of those efforts is described in this report.

2.0 Project Scope and Location Summary

2.1 Project Scope

The scope of this study involved using temporary flow monitors to quantify wastewater flow at the designated locations (Table 1.1). Specifically, the study included the following key components.

- Investigate the proposed flow-monitoring sites for adequate hydraulic conditions and traffic control requirements
- Flow monitor installations
- Flow monitor confirmations and data collections
- Flow data analysis

2.2 Location Summary

Table 1.1 – Flow meters, their identification numbers, location, and metering periods are summarized.

Table 1.1

Meter ID	Site #	Meter Type	Pipe Size (in)	Installation Date	Removal Date
SSMH3N1WSE220001	Site 01	D/V	24	10-Jun-08	27-Jun-08
SSMHN1WNW220012	Site 02	D/V	30	09-Jun-08	27-Jun-08
SSMH3N1WNW220001	Site 03	D/V	30	09-Jun-08	26-Jun-08
Alternate Location	Site 04	D/V	27	11-Jun-08	27-Jun-08
SSMH3N1WSW020046	Site 05	D/V	12	10-Jun-08	27-Jun-08
SSMH4N1WSW330113	Site 06	D/V	24	09-Jun-08	26-Jun-08
SSMH3N1WSW170111	Site 07	D/V	24	09-Jun-08	26-Jun-08
SSMH4N1WSW320090	Site 08	D/V	21	09-Jun-08	26-Jun-08
SSMH3N1WSW160002	Site 09	D/V	24	09-Jun-08	26-Jun-08
SSMH3N1WNW220005	Site 10	D/V	48	10-Jun-08	27-Jun-08
SSMH3N1WNE190089	Site 11	D/V	26	09-Jun-08	26-Jun-08
SSMH4N1WSW310016	Site 12	D/V	18	09-Jun-08	26-Jun-08
SSMH3N1WSW170115	Site 13	D/V	30	11-Jun-08	27-Jun-08
SSMH3N2WSE010107	Site 14	D/V	18	10-Jun-08	26-Jun-08
SSMH3N2WSE120003	Site 15	D/V	18	10-Jun-08	26-Jun-08
SSMH4N2WSE010020	Site 16	D/V	24	09-Jun-08	26-Jun-08

Table 1.2 – The following Flow Monitoring Summary Table contains a summary of important flow data and a numerical and narrative description of each meter location. Additional site detail is contained in enclosed site sheets.

CITY OF SURPRISE FLOW MONITORING STUDY

Table 1.2 - Flow Monitoring Summary

Site #	Location	Pipe Diam. (in)	Avg. Depth (in)	Peak Depth (in)	d/D Max. Peak Depth / Diam.	d/D Min. Min Depth/ Diam.	Avg. Vel. (fps)	Peak Vel. (fps)	Avg Daily Flow (mgd or gpm)	Peak Flow (mgd or gpm)	Peaking Factor Peak Flow / Avg Flow
01	Outside WRF near Cactus and Dysart	24.00	6.71	8.46	35.3%	18.4%	2.37	3.04	1.13	1.90	1.68
02	Inside WRF off 136th and Cactus	30.00	4.45	6.76	22.5%	7.5%	6.83	7.92	2.09	4.13	1.98
03	Litchfield Line - North	30.00	4.81	6.54	21.8%	9.1%	2.84	3.47	0.97	1.74	1.80
04	Reems Road S of Waddell Road	27.00	4.41	5.41	20.0%	13.7%	4.96	6.29	1.39	2.28	1.64
05	16011 N Dysart Road	12.00	2.52	3.69	30.8%	12.3%	1.72	2.30	0.14	0.29	2.03
06	Litchfield Road N of Bell Road	24.00	4.00	5.10	21.2%	11.1%	1.71	2.15	0.39	0.64	1.64
07	Reems Road S of W Larkspur Drive	24.00	4.47	6.70	27.9%	12.0%	5.23	6.46	1.41	2.91	2.07
08	Reems Road at Brookside Lane	21.00	2.70	4.66	22.2%	7.3%	1.64	2.36	0.20	0.60	2.94

Table 1.2 - Flow Monitoring Summary Continued

Site Number	Location	Pipe Diam. (in)	Avg. Depth (in)	Peak Depth (in)	d/D Max. Peak Depth / Diam.	d/D Min. Min Depth/ Diam.	Avg. Vel. (fps)	Peak Vel. (fps)	Avg Daily Flow (mgd or gpm)	Peak Flow (mgd or gpm)	Peaking Factor Peak Flow / Avg Flow
09	Bullard Avenue and Charter Oaks	24.00	4.35	6.87	28.6%	9.92%	2.05	2.64	0.54	1.27	2.34
10	Litchfield Lane - South	48.00	12.90	37.59	78.3%	10.7%	1.07	1.86	1.43	4.93	3.45
11	Reems Road S of Sunnyside Drive	26.00	3.79	5.27	20.3%	10.4%	5.03	6.04	1.11	2.00	1.81
12	Sunrise Blvd N of Bell Road	18.00	1.94	3.24	18.0%	6.9%	3.46	5.30	0.25	0.73	2.95
13	W Cactus W of 153rd Avenue	30.00	5.30	7.57	25.2%	12.6%	4.59	5.81	1.80	3.62	2.01
14	Greenway Road E of Hwy 303	18.00	5.73	7.46	41.4%	20.7%	1.50	2.09	0.49	0.87	1.78
15	Waddell Road ¼ mile from Hwy 303	18.00	4.13	6.81	37.8%	10.4%	1.45	2.12	0.30	0.62	2.09
16	163rd Avenue S of Desert Oasis Blvd	24.00	1.60	2.12	8.8%	4.5%	1.78	2.51	0.11	0.21	1.94

3.0 Site Verification

IEC Field Application Specialists performed flow meter site visits three times following initial installation to confirm satisfactory equipment operation and to collect depth, velocity and flow measurements. To verify meter operation, IEC conducts *point velocity and depth measurements* which is the collection of depth and velocity measurements at specific points across the channel cross section. Meter verifications are independent of meter equipment measurements. Manual depths of flow (DOF) measurements are performed using a ruled tape. Velocity measurements are taken using a handheld point-velocity measurement probe. Depth measurement is used for direct comparison or to verify an offset value if the sensor is not mounted on the invert of the pipe. The velocity measurements are used as a guide to verify proper operation of the velocity sensor. Handheld velocity measurements cannot be directly compared to meter measurements due to spatial and temporal differences between the two measurements.

Every installed flow meter on this project met or exceeded engineering performance specifications. High quality flow data was collected at each location.

4.0 Equipment and Principles of Operation

4.1 Equipment

Open channel flow for this project was measured with temporary flow meters at sixteen (16) locations. The flow meters used by IEC use various depth measurement and velocity measurement technologies. Each of the technologies will provide data of high quality when properly applied to specific environmental, hydraulic and physical conditions. The sensors were mounted on an expandable aluminum ring installed in the sewer pipe, normally upstream from the manhole invert. The signal from the sensors was transmitted to the monitor through a communications cable.

IEC carries a variety of flow monitoring products for all pipe capacities and types and are not bound by a specific manufacturer. In an open channel, temporary flow monitoring project, IEC primarily utilizes the **ADFM® Pro20 Velocity Profiler** and the **2150 Area Velocity Module (AV)**. These flow meters meet equipment criteria for depth and velocity measurements, five minute sampling and data storage. The actual flow meter used at each location and installation method will be determined based on an evaluation of site conditions including but not limited to pipe size, expected minimum depth, expected maximum depth, expected minimum velocity, silt levels, water quality, presence of debris and surcharge evidence.
For the City of Surprise project, two meter types were used, the ADFM™ Pro20 and the Isco 2150 Area Velocity (AV). The flow meters were programmed to record the measured flow depth and velocity at 5-minute intervals.

ADFM® Pro20 Velocity Profiler

The ADFM® Pro20 (ADFM) is particularly well suited for use in pipes larger than 24 inches in diameter that have minimum depths of flow of eight inches delivering flow rate data within 2% of actual value, in flow depths up to 20 feet. The ADFM uses a combination level/velocity transducer featuring an upward-looking ultrasonic level sensor and advanced pulse Doppler technology to accurately measure velocities at multiple points throughout the wetted cross-section. Pulse Doppler technology gives a very accurate velocity measurement, and therefore a more accurate flow rate measurement than traditional continuous wave Doppler flow meters. This includes environments with very slow or fast velocities, as well as during backup and reversed flow conditions.

The ADFM is capable of measuring flows when flows are periodically too shallow to measure velocities. Since the flow pattern and measured velocity distribution are dependent upon each other, the ADFM's advanced flow algorithms automatically adapt to changing hydraulic conditions within the pipe.

2150 Area Velocity Module (AV)

The 2150 Flow Module uses continuous wave Doppler technology to measure mean velocity. IEC typically uses the 2150 area velocity flow meters for pipe sizes 30" and less use continuous wave Doppler technology to measure mean velocity. The sensor transmits a continuous ultrasonic wave and measures the frequency shift of returned echoes reflected by air bubbles or particles in the flow. The 500 KHz Doppler is ideal for applications such as sewer flow monitoring, I&I Studies, combined sewer overflow (CSO) monitoring, and storm water runoff monitoring.

4.2 Principles of Operation

ADFM® Pro20 Velocity Profiler

Four (4) piezoelectric ceramics in the sensor emit short pulses along narrow acoustic beams pointing in different directions to measure velocity. A fifth ceramic mounted in the center of the sensor assembly, and aimed vertically, is used to measure the depth. Each acoustic beam measures velocity at multiple points, or "bins", within the water column. The measured velocity data within each bin are very precise – to within 0.01 ft/s. The measurements are then used to determine the flow pattern over the entire flow cross-section. Since the flow pattern and measured velocity distribution are dependent on each other, the Pro20's advanced flow algorithms automatically adapt to changing hydraulic conditions. This removes the need for in-situ calibration and insures accurate flow rate measurement over a host of different measurement environments and hydraulic conditions.

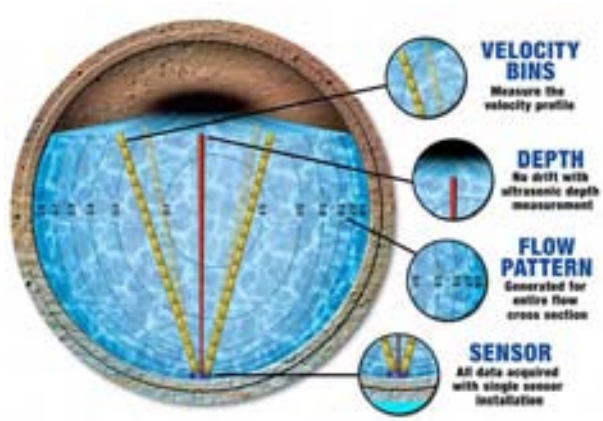

Image Courtesy of Teledyne Isco

2150 Area Velocity Module (AV)

The area velocity method is one method commonly used for automatically measuring open channel flow. A Doppler flow meter (area-velocity meter) operates by emitting into the flow ultrasonic waves of known frequency and duration from a transmitter located in the channel invert. Suspended particles and air bubbles in the flow reflect the emitted waves. The sensor receives and detects the deflected frequencies, and processes them to determine the average velocity. The area velocity method calculates flow rate by multiplying the area of the flow by its average velocity. This is often referred to as the *continuity equation*, **Q = A * V.** The main advantage of the area velocity method is that it can be used to measure flow under a wide range of conditions such as open channel, surcharged, full pipe, submerged and reverse flow. You don't have to estimate the slope and roughness of the channel, and silt correction allows you to compensate for debris that accumulates on the bottom of the channel.

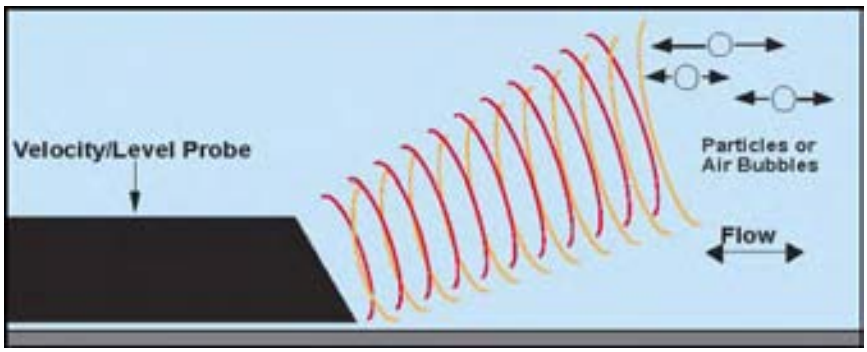

Image Courtesy of Teledyne Isco

5.0 Data Presentation

This section of the report provides a detailed description of the flow meter station information and flow data provided for each meter location. Flow meter station information and flow meter data graphs and tabular data are provided for the each meter location at the end of this report.

5.1 Field Investigation Reports

The Field Investigation Report consists of the Temporary Flow Monitoring (TFM) Site Information Form. The TFM Site Information Form provides an illustration of the physical location of each flow monitoring station. Pertinent information relative to site access, safety, instrumentation, additional notes, and hydraulic conditions are listed. Manhole Condition and Site Calibration documents are kept on file for **reference only**.

5.2 Site Summary Sheet

The Site Summary Sheet is provided for a quick overview of the flow monitoring results at each site. It contains the average, minimum, and maximum values for depth of flow, average velocity, and flow rate over the duration of the monitoring period and a flow data hydrograph.

5.3 Hydrograph (Times Series) Data Presentation

A graphical time series presentation of flow Depth (inches), Average Velocity (feet/second), and Flow Rate (mgd) is provided for each site. Graphs are created using 15-minute averages of the measured data. The stacked axis allows easy visual identification of system performance.

5.4 Scattergraphs

Scattergraphs, or X-Y plots of observed average velocities and flow rates versus observed depths, are provided for each site. These plots provide a graphical representation of hydraulic conditions at the sites. These graphs are particularly useful for showing a site's hydraulic reaction to conditions such as backwater and surcharge.

For this report, there are two different types of scattergraphs, the Flow Rate vs. Depth and the Average Velocity vs. Depth. The Flow Rate vs. Depth scattergraph is different from the Average Velocity vs. Depth scattergraph. Average velocity, by definition, is the flow rate Q divided by the area A. In a circular pipe, area is not a linear function of the depth, so therefore the two scattergraphs have different shapes.

5.5 Tabular Data Presentation

Tabular presentations of Flow Rate (mgd), Average Velocity (ft/s) and Depth (inches) are provided as a function of time of day and date. The flow monitors recorded data at all monitoring locations at 5-minute intervals. The tabular information in this report provides hourly averages of these 5-minute recordings. For example, all flow rate, or discharge measurements recorded from 00:00 through 00:59 for a given day are reported as an hourly average on row one (1) of the tabular report.

Hourly averages of the measured data are provided for each day of monitoring as well as the average, hourly minimum and maximum and instantaneous minimum and maximum values.

At the bottom of each day's column of hourly average data are summary statistics for that day, as follows:

- The *"Mean"* is the average of all instantaneous readings recorded during that day.
- The *"Maximum Hourly Mean"* is the maximum hourly average shown in the hours 0 through 24.
- The *"Minimum Hourly Mean"* is the minimum hourly average shown in the hours 0 through 24.
- The *"Instantaneous Maximum"* is the greatest single reading data value obtained during the day.
- The *"Instantaneous Minimum"* is the smallest single reading data value obtained during the day.

5.6 Electronic Data Presentation

Final data reports are produced in electronic format allowing a complete data report, including all data plots and photographs. Flow rate, depth and average velocity data in 15-minute increments are transmitted electronically to the client.

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 01
Address: Outside WRF at N Dysart Road
MH ID# SSMH3N1WSE220001

Date: 06/10/08
GPS: 33.352687N -112.203570W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 204M01443
Sensor Serial # 204K00796
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Down Manhole

Hydraulics:
Moderate to fast flow conditions.

Comments:
All site conditions confirmed safe to enter. Good monitoring location.

Photos
MH #SSMH3N1WSE220001
Site #01

Site ID

Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

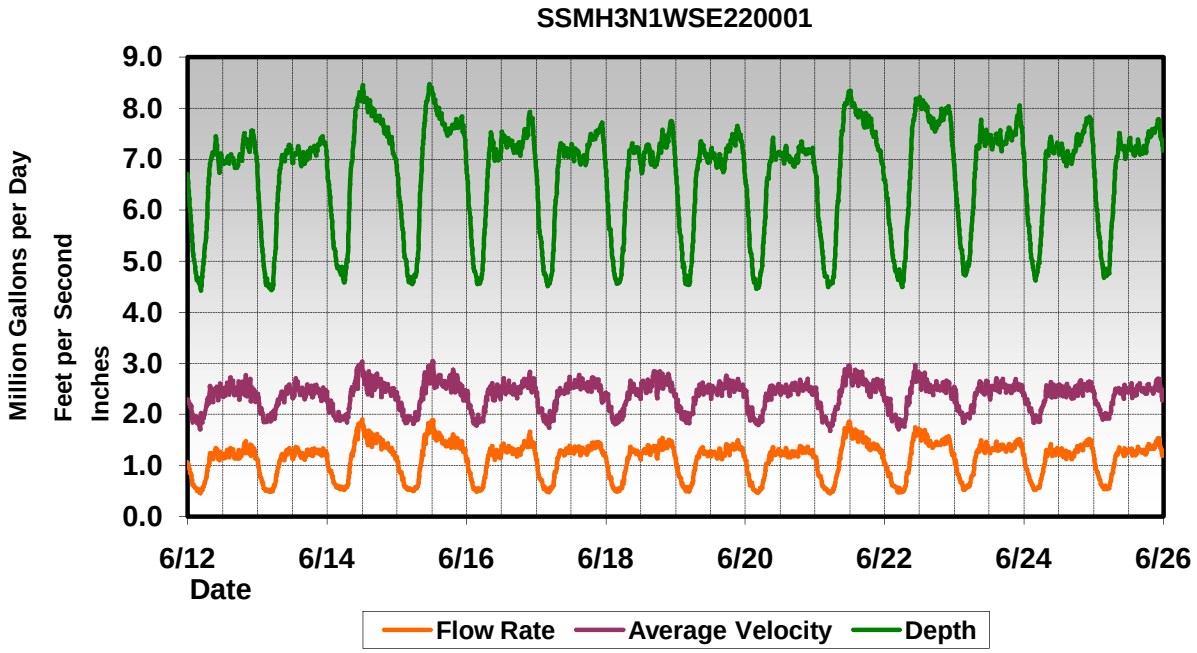
Site	**SSMH3N1WSE220001**
Address	**Outside WRF near Cactus and Dysart**
Diameter	**24** Inches
GPS	**33.352687N -112.203570W**

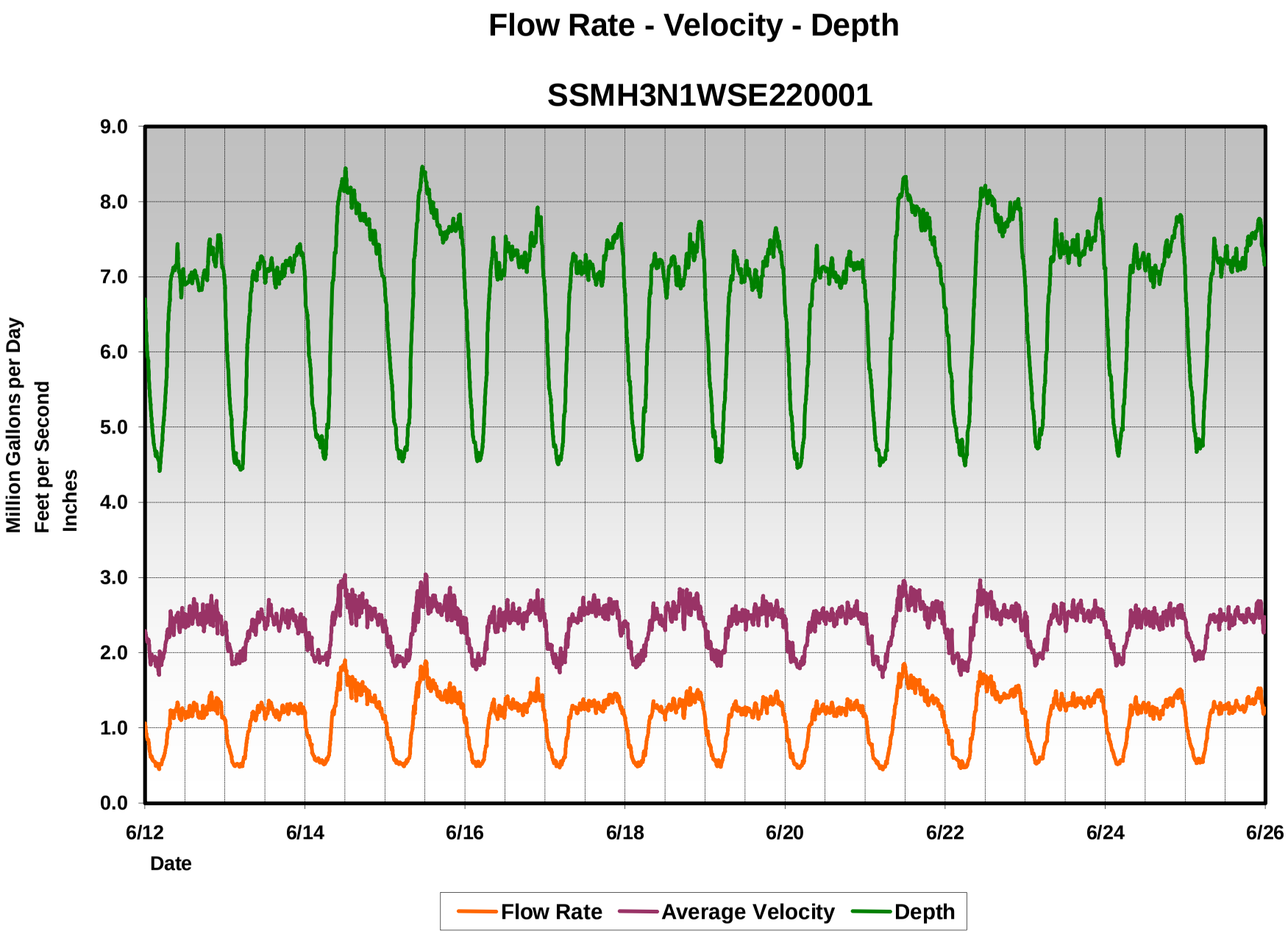
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	6.71
Maximum	8.46
Minimum	4.42
Max d/D	35.3%

Flow velocity	
	Feet per Second
Average	2.37
Maximum	3.04
Minimum	1.67

Flow Rate	
	Million Gallons per Day
Average	1.13
Maximum	1.90
Minimum	0.45
Peak Factor	1.68



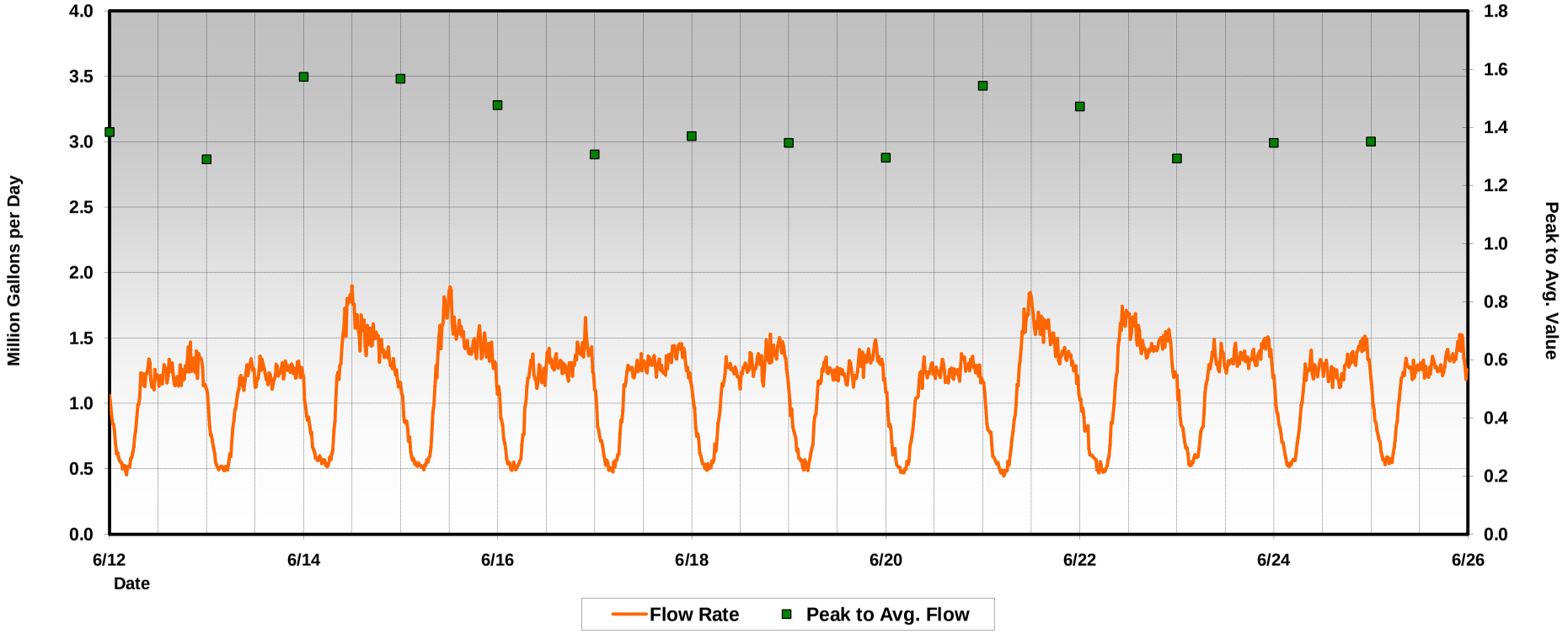

Flow Rate - Velocity - Depth
SSMH3N1WSE220001
Million Gallons per Day
Feet per Second
Inches
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

Peak to Average Flow Rate

Site ID SSMH3N1WSE220001

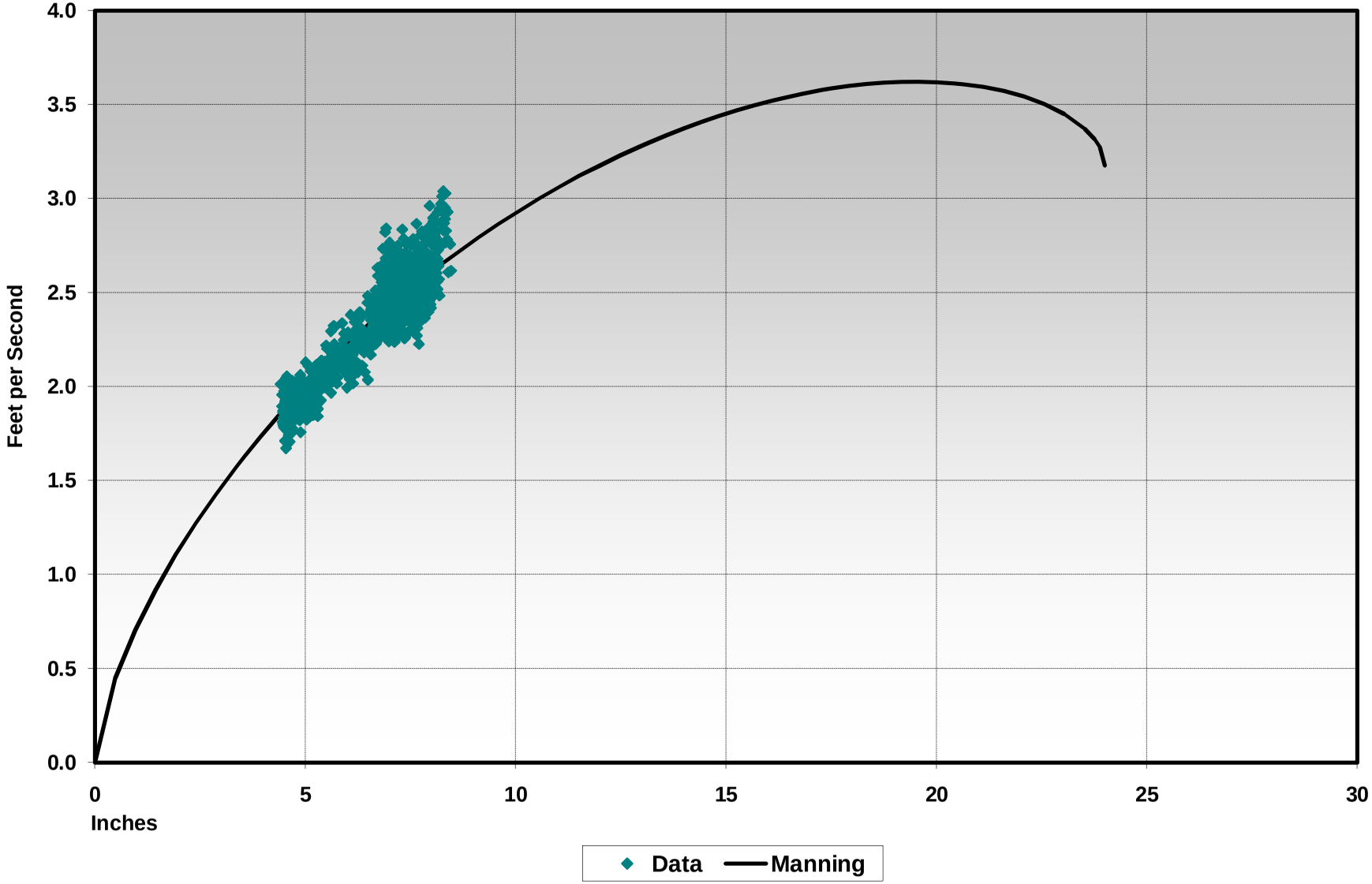
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.38	1.29	1.57	1.57	1.48	1.31	1.37	1.35	1.30	1.54	1.47	1.29	1.35	1.35



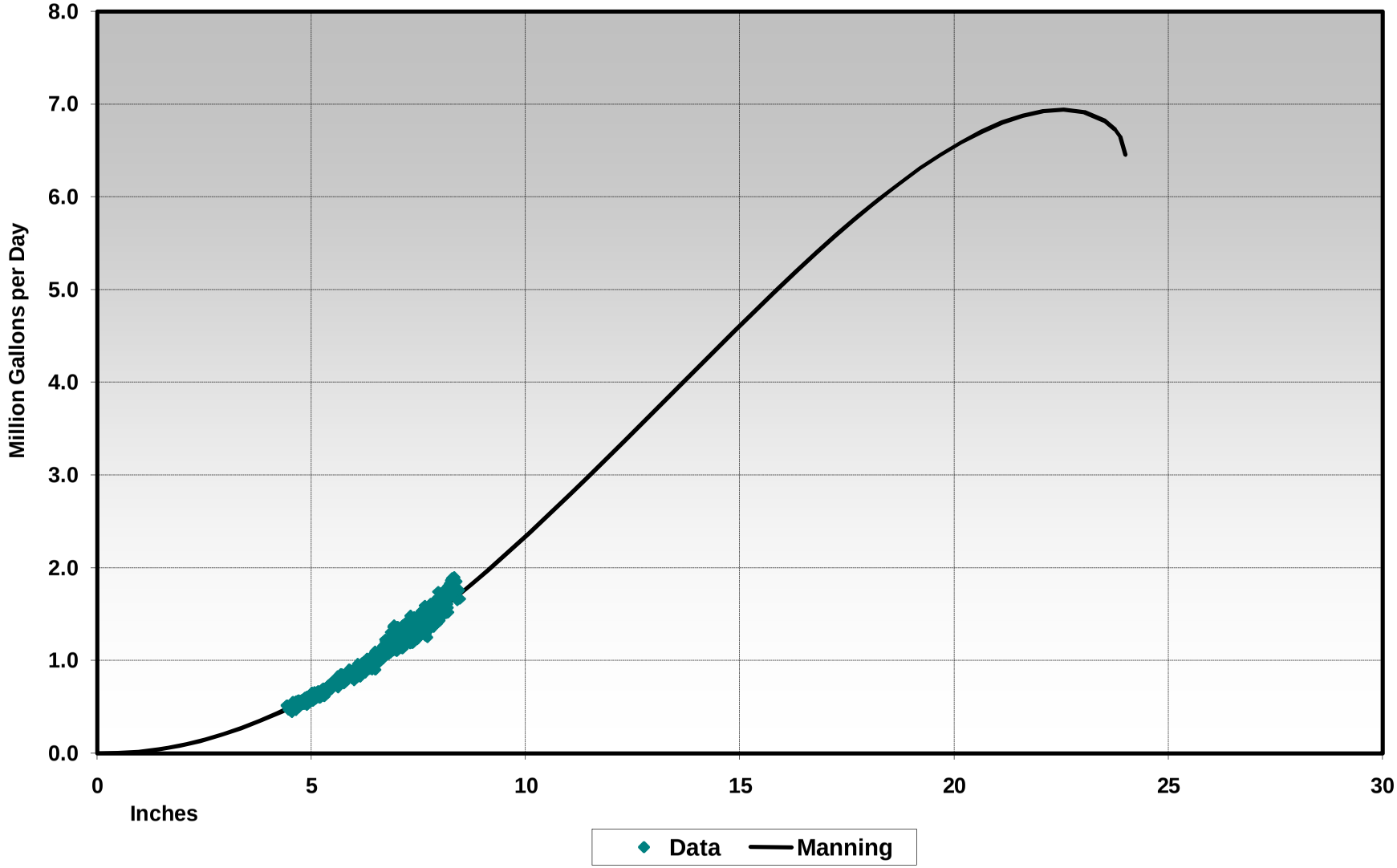
Velocity vs. Depth Scattergraph

SSMH3N1WSE220001



Flow Rate vs. Depth Scattergraph

SSMH3N1WSE220001



Flow Rate - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.96	1.00	1.03	1.05	1.04	1.00	1.04	1.00	0.99	1.09	0.99	1.06	1.06	1.07
1:00	0.74	0.72	0.84	0.84	0.78	0.74	0.76	0.78	0.74	0.80	0.82	0.81	0.83	0.82
2:00	0.58	0.55	0.68	0.67	0.58	0.59	0.58	0.61	0.59	0.66	0.67	0.66	0.67	0.66
3:00	0.52	0.51	0.57	0.56	0.51	0.53	0.51	0.53	0.50	0.55	0.59	0.54	0.54	0.56
4:00	0.49	0.50	0.56	0.53	0.52	0.50	0.51	0.53	0.48	0.49	0.50	0.58	0.55	0.57
5:00	0.58	0.54	0.55	0.51	0.55	0.56	0.59	0.60	0.54	0.47	0.51	0.64	0.61	0.60
6:00	0.77	0.74	0.56	0.55	0.79	0.78	0.77	0.84	0.74	0.54	0.50	0.84	0.85	0.85
7:00	1.07	1.01	0.73	0.66	1.13	1.10	1.07	1.13	1.00	0.76	0.68	1.16	1.15	1.13
8:00	1.18	1.17	1.16	1.08	1.32	1.27	1.26	1.25	1.18	1.04	0.97	1.32	1.24	1.27
9:00	1.26	1.17	1.39	1.42	1.17	1.23	1.28	1.28	1.25	1.40	1.35	1.38	1.29	1.28
10:00	1.20	1.27	1.65	1.61	1.23	1.27	1.26	1.25	1.23	1.61	1.63	1.29	1.26	1.24
11:00	1.19	1.29	1.79	1.71	1.20	1.29	1.21	1.21	1.27	1.76	1.66	1.38	1.30	1.26
12:00	1.19	1.16	1.75	1.80	1.35	1.30	1.21	1.24	1.23	1.70	1.60	1.28	1.27	1.28
13:00	1.22	1.30	1.59	1.56	1.31	1.31	1.28	1.23	1.23	1.60	1.64	1.32	1.24	1.26
14:00	1.24	1.24	1.55	1.56	1.31	1.33	1.32	1.18	1.26	1.62	1.52	1.38	1.22	1.23
15:00	1.26	1.19	1.51	1.52	1.30	1.28	1.26	1.28	1.20	1.58	1.43	1.33	1.22	1.32
16:00	1.17	1.16	1.48	1.43	1.27	1.28	1.33	1.18	1.23	1.55	1.38	1.37	1.16	1.26
17:00	1.18	1.25	1.52	1.40	1.24	1.26	1.24	1.32	1.25	1.50	1.42	1.32	1.25	1.25
18:00	1.23	1.26	1.47	1.43	1.29	1.34	1.37	1.31	1.26	1.41	1.42	1.35	1.32	1.32
19:00	1.31	1.26	1.44	1.51	1.37	1.40	1.37	1.36	1.32	1.36	1.44	1.33	1.35	1.36
20:00	1.33	1.26	1.37	1.43	1.40	1.39	1.41	1.34	1.27	1.37	1.48	1.37	1.35	1.35
21:00	1.27	1.27	1.34	1.44	1.49	1.42	1.44	1.44	1.31	1.37	1.49	1.46	1.44	1.41
22:00	1.35	1.26	1.27	1.39	1.42	1.34	1.44	1.32	1.26	1.28	1.47	1.47	1.46	1.49
23:00	1.17	1.24	1.18	1.26	1.32	1.22	1.29	1.25	1.21	1.18	1.22	1.32	1.36	1.27
Average	1.06	1.05	1.21	1.21	1.12	1.11	1.12	1.10	1.06	1.20	1.18	1.17	1.12	1.13
Median	1.18	1.19	1.33	1.38	1.24	1.25	1.25	1.22	1.21	1.33	1.40	1.30	1.24	1.25
Max Hr. Mean	1.35	1.30	1.79	1.80	1.49	1.42	1.44	1.44	1.32	1.76	1.66	1.47	1.46	1.49
Min Hr. Mean	0.49	0.50	0.55	0.51	0.51	0.50	0.51	0.53	0.48	0.47	0.50	0.54	0.54	0.56
Inst. Max	1.47	1.36	1.90	1.89	1.65	1.46	1.53	1.48	1.38	1.85	1.74	1.51	1.51	1.53
Inst. Min	0.45	0.49	0.52	0.49	0.49	0.48	0.49	0.49	0.47	0.45	0.47	0.53	0.52	0.53

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.22	2.28	2.22	2.30	2.31	2.27	2.38	2.24	2.28	2.40	2.26	2.36	2.30	2.33
1:00	2.04	2.06	2.14	2.13	2.11	2.09	2.12	2.11	2.05	2.13	2.11	2.10	2.20	2.17
2:00	1.93	1.89	2.02	1.95	1.90	1.96	1.89	1.96	1.99	2.00	2.00	2.00	2.06	2.03
3:00	1.89	1.90	1.91	1.88	1.83	1.91	1.86	1.91	1.87	1.94	1.96	1.88	1.87	1.94
4:00	1.86	1.92	1.95	1.91	1.90	1.87	1.89	1.93	1.83	1.81	1.80	1.97	1.93	1.98
5:00	1.93	1.99	1.92	1.88	1.89	1.92	1.99	2.01	1.88	1.76	1.83	2.00	1.92	1.98
6:00	2.15	2.09	1.93	1.92	2.14	2.08	2.11	2.20	2.11	1.92	1.81	2.12	2.15	2.21
7:00	2.33	2.27	2.04	1.98	2.40	2.35	2.34	2.40	2.33	2.11	2.03	2.38	2.36	2.43
8:00	2.36	2.38	2.42	2.35	2.51	2.45	2.47	2.47	2.46	2.31	2.28	2.54	2.44	2.48
9:00	2.46	2.38	2.54	2.60	2.31	2.43	2.49	2.49	2.46	2.56	2.55	2.51	2.45	2.45
10:00	2.40	2.48	2.75	2.66	2.47	2.50	2.46	2.51	2.46	2.69	2.78	2.45	2.47	2.44
11:00	2.45	2.50	2.91	2.71	2.42	2.59	2.41	2.48	2.52	2.86	2.75	2.59	2.51	2.49
12:00	2.46	2.34	2.81	2.91	2.55	2.56	2.55	2.46	2.46	2.77	2.66	2.40	2.50	2.45
13:00	2.49	2.59	2.62	2.61	2.48	2.59	2.54	2.48	2.49	2.69	2.73	2.52	2.45	2.47
14:00	2.53	2.46	2.61	2.68	2.52	2.64	2.55	2.45	2.50	2.77	2.56	2.57	2.47	2.41
15:00	2.54	2.44	2.57	2.65	2.48	2.62	2.55	2.58	2.43	2.71	2.50	2.50	2.44	2.57
16:00	2.44	2.35	2.56	2.58	2.48	2.59	2.72	2.51	2.53	2.70	2.46	2.65	2.37	2.48
17:00	2.42	2.50	2.65	2.57	2.41	2.55	2.56	2.63	2.55	2.65	2.56	2.52	2.45	2.46
18:00	2.49	2.48	2.59	2.61	2.50	2.53	2.68	2.55	2.50	2.49	2.52	2.50	2.46	2.50
19:00	2.47	2.45	2.58	2.73	2.60	2.63	2.61	2.55	2.55	2.45	2.50	2.46	2.56	2.52
20:00	2.53	2.49	2.51	2.55	2.59	2.58	2.68	2.52	2.51	2.54	2.57	2.53	2.49	2.45
21:00	2.46	2.43	2.50	2.58	2.66	2.59	2.70	2.62	2.59	2.65	2.53	2.61	2.55	2.55
22:00	2.49	2.38	2.43	2.46	2.52	2.40	2.56	2.49	2.49	2.55	2.52	2.53	2.55	2.62
23:00	2.31	2.40	2.38	2.37	2.56	2.35	2.42	2.49	2.43	2.49	2.36	2.45	2.52	2.42
Average	2.32	2.31	2.40	2.40	2.36	2.38	2.40	2.38	2.34	2.41	2.36	2.38	2.35	2.37
Median	2.38	2.38	2.47	2.51	2.43	2.46	2.45	2.47	2.45	2.53	2.47	2.47	2.42	2.45
Max Hr. Mean	2.54	2.59	2.91	2.91	2.66	2.64	2.72	2.63	2.59	2.86	2.78	2.65	2.56	2.62
Min Hr. Mean	1.86	1.89	1.91	1.88	1.83	1.87	1.86	1.91	1.83	1.76	1.80	1.88	1.87	1.94
Inst. Max	2.76	2.70	3.03	3.04	2.83	2.77	2.84	2.75	2.69	2.95	2.96	2.70	2.66	2.69
Inst. Min	1.71	1.85	1.84	1.82	1.78	1.74	1.81	1.83	1.79	1.67	1.71	1.83	1.83	1.90

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSE220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	6.35	6.40	6.67	6.62	6.55	6.45	6.41	6.51	6.39	6.61	6.43	6.56	6.70	6.63
1:00	5.58	5.47	5.98	5.98	5.71	5.54	5.61	5.71	5.59	5.79	5.92	5.85	5.80	5.78
2:00	4.95	4.84	5.33	5.39	4.98	4.95	5.01	5.06	4.90	5.27	5.33	5.25	5.21	5.23
3:00	4.65	4.56	4.92	4.89	4.67	4.65	4.65	4.66	4.56	4.76	4.92	4.76	4.78	4.79
4:00	4.51	4.48	4.81	4.66	4.60	4.56	4.60	4.61	4.49	4.59	4.69	4.86	4.76	4.78
5:00	4.90	4.59	4.74	4.59	4.82	4.84	4.90	4.92	4.76	4.57	4.68	5.17	5.14	4.97
6:00	5.58	5.53	4.79	4.73	5.70	5.73	5.65	5.82	5.48	4.72	4.66	6.00	5.97	5.83
7:00	6.62	6.50	5.54	5.30	6.78	6.72	6.63	6.77	6.35	5.61	5.29	6.95	6.91	6.72
8:00	7.08	6.98	6.86	6.65	7.34	7.24	7.17	7.14	6.85	6.56	6.31	7.26	7.15	7.21
9:00	7.20	7.01	7.53	7.54	7.15	7.16	7.21	7.24	7.15	7.53	7.35	7.57	7.33	7.30
10:00	7.06	7.18	8.09	8.12	7.06	7.14	7.19	7.08	7.05	8.06	7.94	7.34	7.17	7.16
11:00	6.93	7.24	8.22	8.39	7.03	7.08	7.11	6.96	7.12	8.22	8.12	7.40	7.26	7.16
12:00	6.91	7.01	8.30	8.26	7.37	7.15	6.83	7.11	7.09	8.22	8.09	7.40	7.17	7.31
13:00	6.97	7.10	8.16	8.07	7.37	7.13	7.12	7.04	7.04	8.04	8.09	7.29	7.12	7.17
14:00	6.99	7.14	8.02	7.91	7.30	7.10	7.26	6.87	7.13	7.91	8.02	7.45	6.99	7.17
15:00	7.01	6.96	7.95	7.81	7.33	6.95	6.99	7.03	7.00	7.89	7.80	7.40	7.08	7.23
16:00	6.85	6.99	7.85	7.65	7.19	7.04	6.98	6.79	6.92	7.83	7.69	7.26	6.99	7.16
17:00	6.94	7.07	7.79	7.52	7.22	7.02	6.93	7.09	6.98	7.74	7.62	7.31	7.15	7.18
18:00	7.01	7.16	7.75	7.56	7.23	7.36	7.19	7.20	7.09	7.74	7.69	7.48	7.42	7.34
19:00	7.36	7.20	7.65	7.63	7.33	7.42	7.32	7.40	7.24	7.64	7.85	7.48	7.35	7.46
20:00	7.33	7.14	7.53	7.67	7.47	7.45	7.33	7.39	7.15	7.48	7.83	7.48	7.52	7.57
21:00	7.24	7.32	7.45	7.66	7.67	7.55	7.39	7.58	7.15	7.27	7.96	7.70	7.72	7.60
22:00	7.51	7.36	7.31	7.70	7.74	7.66	7.71	7.39	7.15	7.11	7.89	7.89	7.79	7.74
23:00	7.15	7.25	7.02	7.39	7.23	7.26	7.41	7.08	7.05	6.81	7.26	7.44	7.47	7.32
Average	6.53	6.52	6.93	6.90	6.70	6.63	6.61	6.60	6.49	6.83	6.89	6.86	6.75	6.74
Median	6.95	7.05	7.43	7.58	7.18	7.06	7.03	6.99	6.98	7.32	7.66	7.31	7.12	7.17
Max Hr. Mean	7.51	7.36	8.30	8.39	7.74	7.66	7.71	7.58	7.24	8.22	8.12	7.89	7.79	7.74
Min Hr. Mean	4.51	4.48	4.74	4.59	4.60	4.56	4.60	4.61	4.49	4.57	4.66	4.76	4.76	4.78
Inst. Max	7.55	7.44	8.45	8.46	7.92	7.70	7.74	7.65	7.42	8.33	8.21	8.04	7.82	7.78
Inst. Min	4.42	4.44	4.58	4.55	4.55	4.51	4.56	4.54	4.46	4.49	4.50	4.72	4.62	4.67

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 02**	**Date:**	**6/9/08**
Address:	**Inside WRF off 136th near Cactus Road**	**GPS:**	**33.353672N -112.210970W**
MH ID#	**SSMHN1WNW220012**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204L00133**
Sensor Serial #	**205K01554**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert. 30" Horiz. 30"**
Laterals	**2**
Pipe Material	**PVC**
Surcharge Evidence	**No**
Height Above Crown (in)	**0**
Infiltration	**No**
Silt	**No**
Debris	**No**
Grease	**No**
Pests	**No**

Down Manhole

Hydraulics:
Fast flow conditions at time of installation.

Comments:
Lots of TP in flow.

Photos
MH #SSMHN1WNW220012
Site #02

Site ID

Down Manhole

30” Influent

30” Effluent

6” Drop In (Dry)

6” Drop In (Wet)

Photos
MH #SSMHN1WNW220012
Site #02

Manhole Cover Top

Manhole Cover Bottom

Location Summary

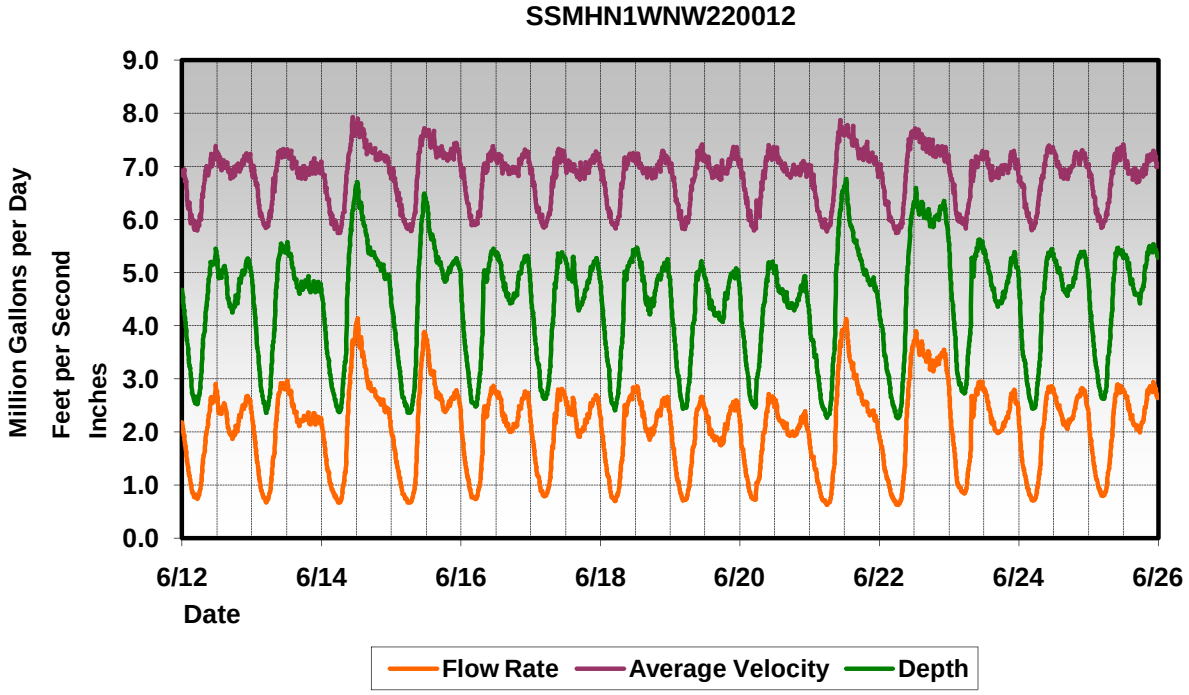
Site	**SSMHN1WNW220012**
Address	**Inside WRF off 136th and Cactus**
Diameter	**30** Inches
GPS	**33.353672N -112.210970W**

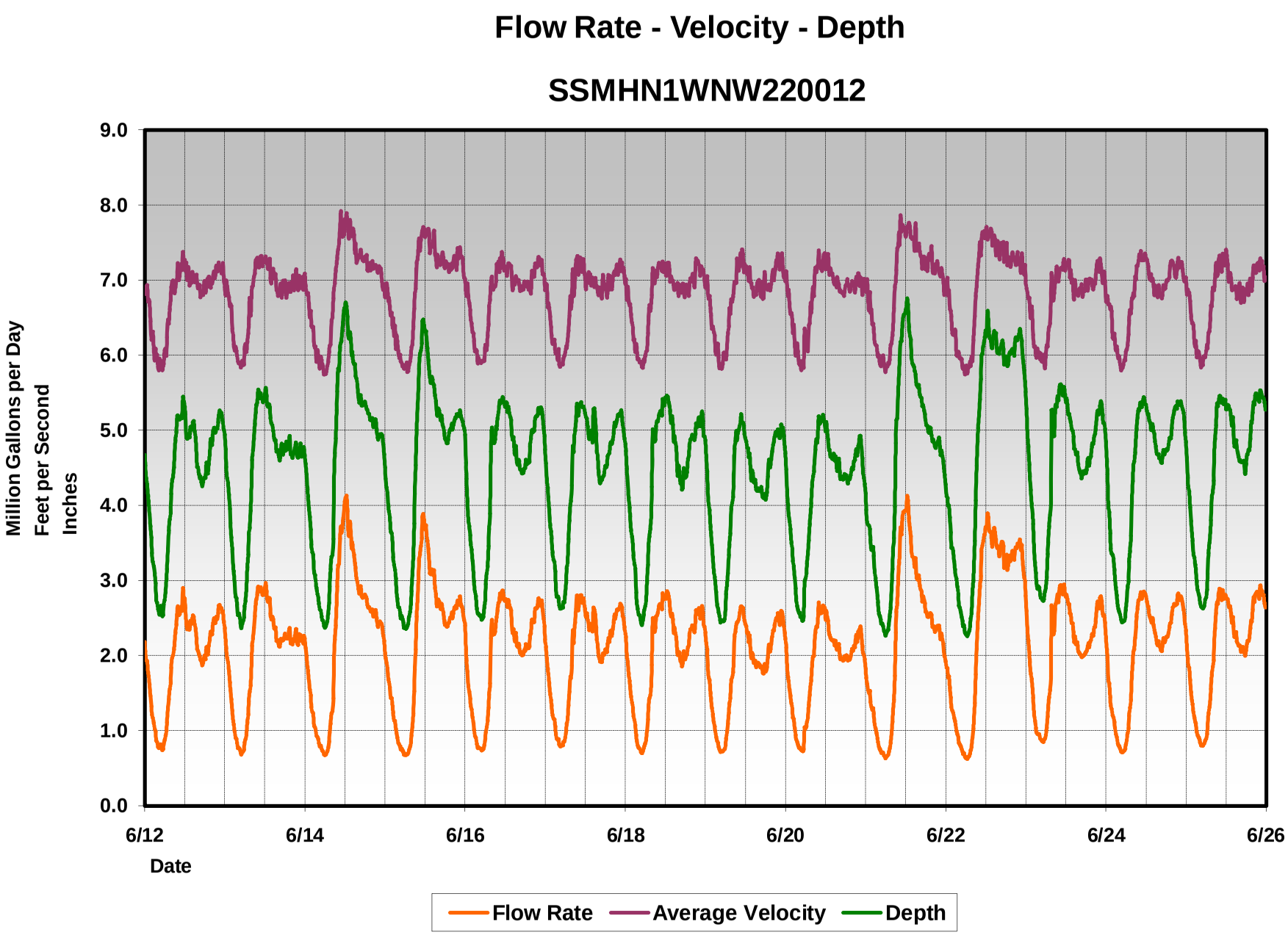
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.45
Maximum	6.76
Minimum	2.26
Max d/D	22.5%

Flow velocity	
	Feet per Second
Average	6.83
Maximum	7.92
Minimum	5.75

Flow Rate	
	Million Gallons per Day
Average	2.09
Maximum	4.13
Minimum	0.63
Peak Factor	1.98



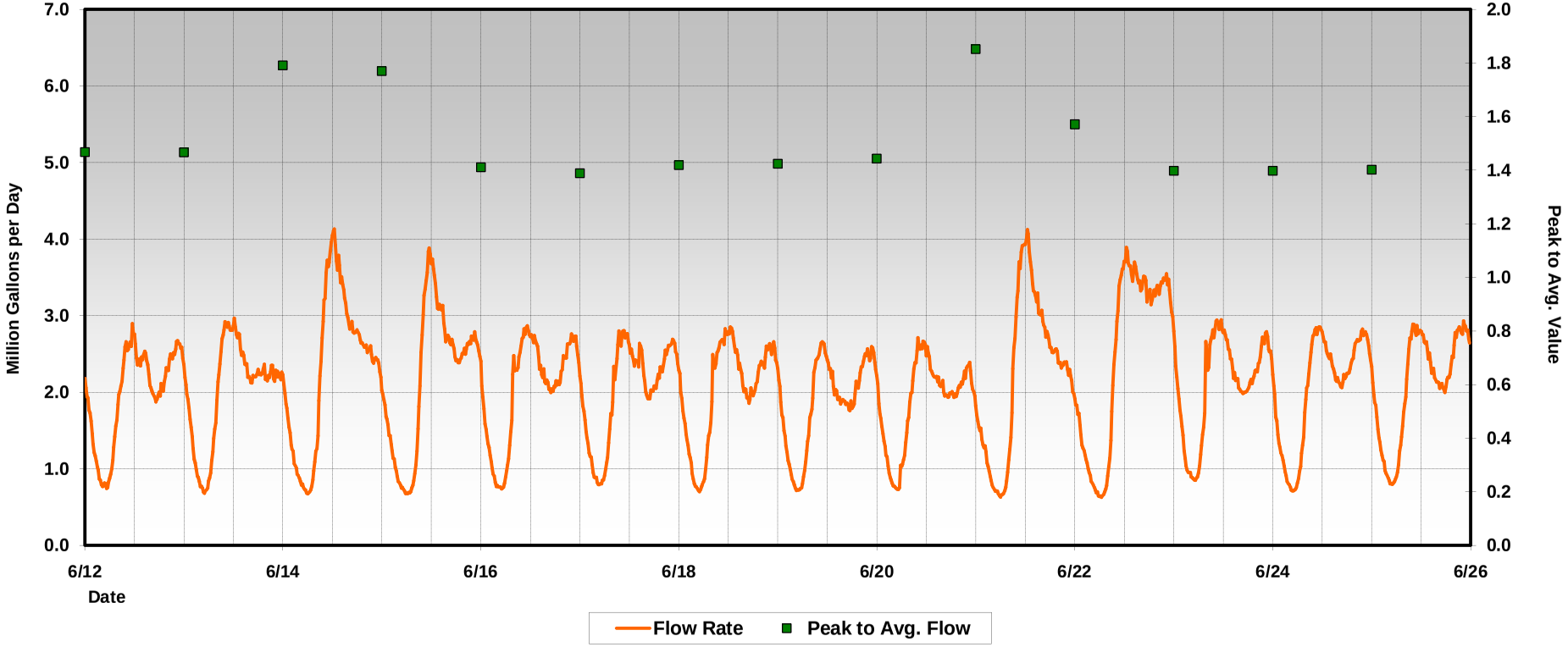

Flow Rate - Velocity - Depth
SSMHN1WNW220012
Million Gallons per Day
Feet per Second
Inches
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

Peak to Average Flow Rate

Site ID SSMHN1WNW220012

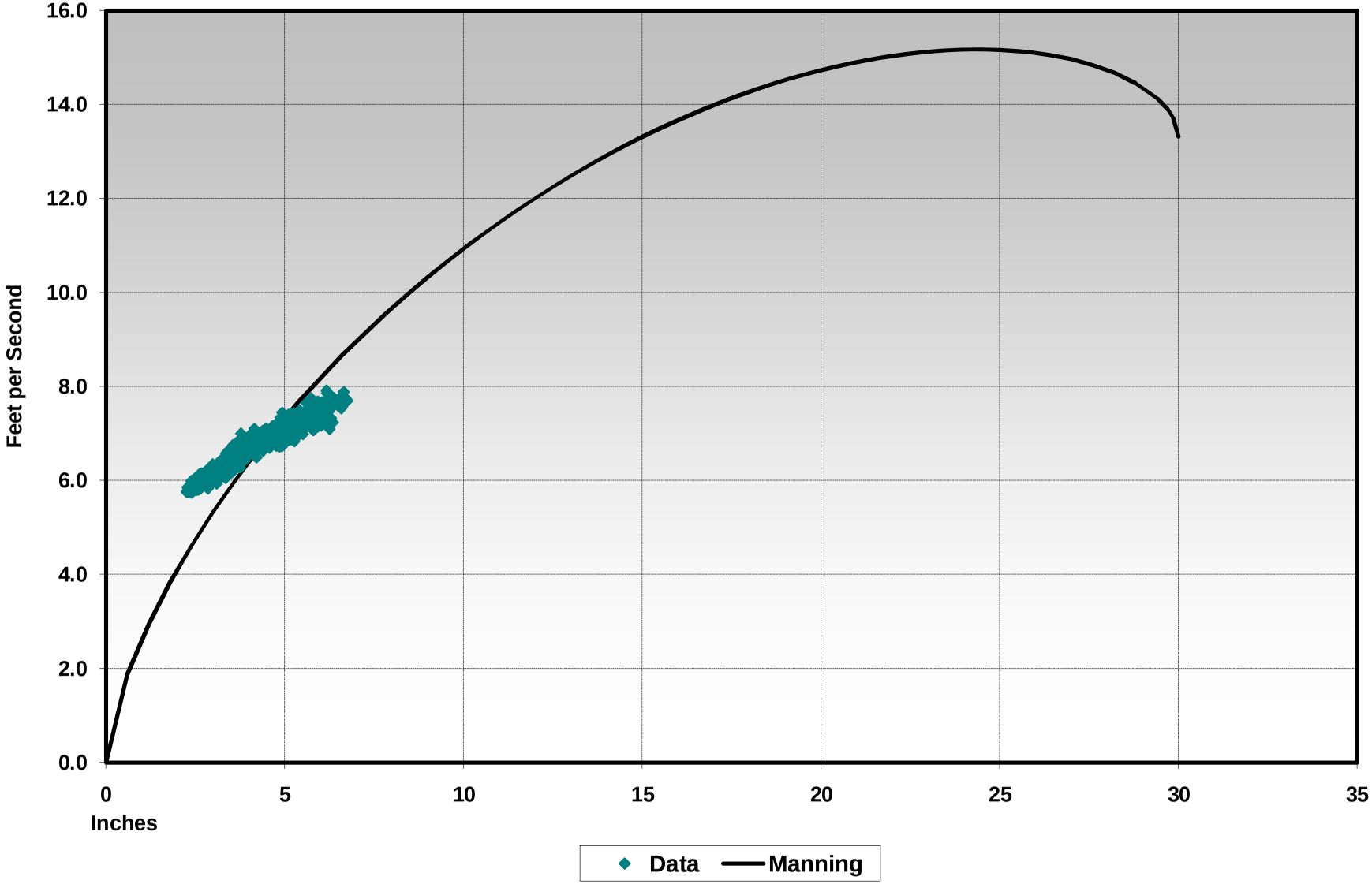
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.47	1.47	1.79	1.77	1.41	1.39	1.42	1.42	1.44	1.85	1.57	1.40	1.40	1.40



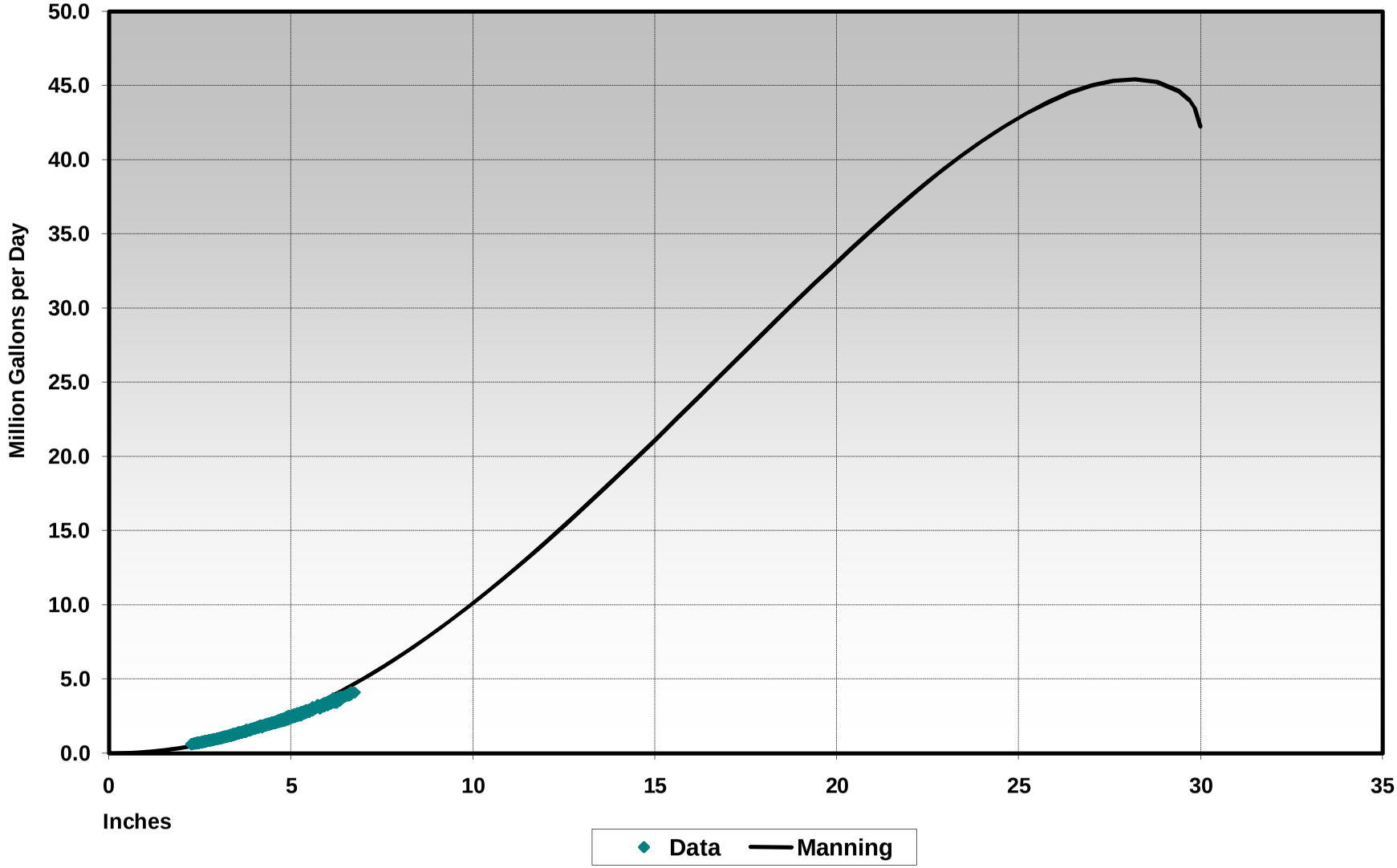
Velocity vs. Depth Scattergraph

SSMHN1WNW220012



Flow Rate vs. Depth Scattergraph

SSMHN1WNW220012



Flow Rate - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.02	2.16	2.04	1.93	2.05	2.03	2.11	2.10	1.97	1.67	1.82	2.48	1.99	2.07
1:00	1.64	1.72	1.62	1.59	1.46	1.57	1.61	1.57	1.51	1.43	1.51	1.85	1.42	1.61
2:00	1.20	1.22	1.21	1.28	1.14	1.21	1.26	1.17	1.17	1.22	1.20	1.34	1.13	1.22
3:00	0.93	0.90	0.97	1.01	0.86	0.94	0.92	0.90	0.87	0.94	0.99	0.98	0.88	0.98
4:00	0.79	0.75	0.83	0.80	0.77	0.82	0.75	0.74	0.76	0.74	0.80	0.90	0.75	0.83
5:00	0.78	0.72	0.72	0.72	0.76	0.83	0.75	0.74	0.81	0.68	0.69	0.87	0.73	0.83
6:00	0.98	0.95	0.69	0.68	1.01	1.03	0.96	0.94	1.10	0.66	0.64	1.12	0.92	1.03
7:00	1.47	1.43	0.92	0.77	1.66	1.57	1.46	1.42	1.53	0.81	0.72	1.84	1.41	1.51
8:00	1.97	2.16	1.45	1.19	2.34	2.17	2.27	1.92	2.00	1.38	1.11	2.45	2.07	2.08
9:00	2.36	2.70	2.56	2.29	2.48	2.64	2.50	2.41	2.40	2.64	2.18	2.73	2.56	2.69
10:00	2.59	2.89	3.43	3.27	2.75	2.74	2.67	2.59	2.62	3.47	3.02	2.90	2.79	2.83
11:00	2.73	2.83	3.78	3.77	2.82	2.72	2.74	2.57	2.63	3.90	3.55	2.87	2.83	2.81
12:00	2.55	2.86	4.05	3.64	2.71	2.54	2.81	2.35	2.51	4.03	3.78	2.76	2.71	2.74
13:00	2.42	2.70	3.69	3.21	2.66	2.40	2.66	2.12	2.26	3.64	3.63	2.56	2.49	2.57
14:00	2.49	2.46	3.42	3.12	2.34	2.49	2.43	1.97	2.18	3.27	3.59	2.30	2.39	2.36
15:00	2.27	2.28	3.10	2.77	2.19	2.32	2.16	1.89	2.12	3.09	3.47	2.14	2.19	2.20
16:00	2.00	2.16	2.87	2.68	2.09	1.95	1.99	1.87	2.02	2.93	3.41	2.01	2.10	2.10
17:00	1.91	2.21	2.78	2.59	2.03	1.99	1.95	1.81	1.96	2.74	3.35	2.00	2.19	2.05
18:00	2.03	2.25	2.76	2.40	2.11	2.09	2.02	1.86	1.97	2.55	3.25	2.10	2.26	2.16
19:00	2.17	2.27	2.62	2.47	2.20	2.27	2.27	2.11	1.99	2.55	3.30	2.20	2.45	2.38
20:00	2.38	2.19	2.57	2.57	2.46	2.40	2.37	2.33	2.10	2.37	3.36	2.33	2.66	2.73
21:00	2.48	2.28	2.52	2.66	2.64	2.56	2.55	2.50	2.24	2.37	3.45	2.61	2.75	2.82
22:00	2.63	2.23	2.42	2.71	2.72	2.65	2.58	2.49	2.34	2.30	3.48	2.73	2.76	2.86
23:00	2.56	2.22	2.32	2.57	2.55	2.51	2.51	2.45	2.03	2.09	3.13	2.51	2.55	2.74
Average	1.97	2.02	2.31	2.19	2.03	2.02	2.01	1.87	1.88	2.23	2.48	2.11	2.04	2.09
Median	2.10	2.21	2.51	2.50	2.23	2.21	2.25	1.93	2.01	2.38	3.19	2.23	2.25	2.19
Max Hr. Mean	2.73	2.89	4.05	3.77	2.82	2.74	2.81	2.59	2.63	4.03	3.78	2.90	2.83	2.86
Min Hr. Mean	0.78	0.72	0.69	0.68	0.76	0.82	0.75	0.74	0.76	0.66	0.64	0.87	0.73	0.83
Inst. Max	2.90	2.97	4.13	3.88	2.87	2.80	2.85	2.66	2.71	4.13	3.89	2.95	2.85	2.93
Inst. Min	0.74	0.68	0.67	0.68	0.74	0.79	0.70	0.72	0.73	0.63	0.63	0.85	0.71	0.80

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	6.87	6.91	6.91	6.88	6.90	6.85	6.90	6.93	6.95	6.89	6.93	6.87	6.74	6.88
1:00	6.66	6.73	6.65	6.67	6.64	6.56	6.65	6.67	6.67	6.65	6.65	6.64	6.63	6.62
2:00	6.20	6.35	6.32	6.42	6.30	6.20	6.30	6.33	6.34	6.34	6.30	6.24	6.23	6.28
3:00	6.00	6.06	6.05	6.23	6.02	6.00	6.06	6.10	6.07	6.07	6.09	6.01	6.03	6.07
4:00	5.87	5.89	5.93	5.99	5.93	5.92	5.92	5.88	5.87	5.90	5.97	5.98	5.87	5.92
5:00	5.87	5.88	5.85	5.86	5.92	5.93	5.88	5.93	5.99	5.89	5.82	5.91	5.90	5.95
6:00	6.10	6.12	5.79	5.84	6.13	6.11	6.10	6.07	6.10	5.84	5.80	6.13	6.13	6.15
7:00	6.56	6.50	6.06	5.90	6.69	6.56	6.61	6.58	6.52	6.03	5.90	6.65	6.60	6.53
8:00	6.96	6.92	6.65	6.32	6.93	6.88	7.00	6.83	6.87	6.54	6.24	6.84	6.86	6.92
9:00	6.95	7.21	7.15	7.05	7.07	7.23	7.10	7.09	7.17	7.25	7.00	7.08	7.16	7.15
10:00	7.12	7.24	7.63	7.48	7.20	7.23	7.20	7.23	7.24	7.66	7.41	7.13	7.33	7.24
11:00	7.22	7.25	7.62	7.66	7.27	7.18	7.18	7.27	7.26	7.70	7.61	7.20	7.29	7.24
12:00	7.16	7.26	7.80	7.62	7.12	7.00	7.16	7.14	7.24	7.66	7.62	7.22	7.24	7.23
13:00	7.05	7.17	7.68	7.53	7.21	7.02	7.10	7.02	7.12	7.66	7.64	7.10	7.03	7.00
14:00	7.03	7.06	7.64	7.52	6.96	6.99	6.94	6.86	7.00	7.50	7.52	6.89	6.92	6.89
15:00	7.00	6.97	7.34	7.29	6.99	6.93	6.92	6.89	6.99	7.49	7.44	6.83	6.86	6.82
16:00	6.89	6.86	7.34	7.25	6.93	6.86	6.87	6.89	6.88	7.37	7.39	6.90	6.80	6.86
17:00	6.84	6.86	7.27	7.29	6.91	6.92	6.88	6.90	6.82	7.27	7.39	6.85	6.88	6.81
18:00	6.94	6.91	7.27	7.21	6.94	6.88	6.88	6.89	6.96	7.21	7.33	6.95	7.00	6.86
19:00	6.97	6.90	7.16	7.17	6.90	7.00	6.93	6.91	6.90	7.35	7.25	7.01	7.19	6.93
20:00	7.02	6.95	7.19	7.23	7.09	7.02	7.01	7.07	6.93	7.14	7.31	6.93	7.16	7.11
21:00	7.10	7.04	7.16	7.27	7.19	7.13	7.24	7.26	6.99	7.20	7.26	7.18	7.18	7.17
22:00	7.16	6.94	7.15	7.34	7.25	7.17	7.16	7.22	7.00	7.09	7.23	7.18	7.21	7.22
23:00	7.12	6.97	6.96	7.20	7.11	7.14	7.10	7.16	6.94	6.94	7.17	7.03	7.05	7.09
Average	6.78	6.79	6.94	6.93	6.82	6.78	6.79	6.80	6.78	6.94	6.93	6.78	6.80	6.79
Median	6.95	6.91	7.15	7.20	6.95	6.92	6.94	6.91	6.92	7.14	7.22	6.91	6.93	6.88
Max Hr. Mean	7.22	7.26	7.80	7.66	7.27	7.23	7.24	7.27	7.26	7.70	7.64	7.22	7.33	7.24
Min Hr. Mean	5.87	5.88	5.79	5.84	5.92	5.92	5.88	5.88	5.87	5.84	5.80	5.91	5.87	5.92
Inst. Max	7.38	7.32	7.92	7.71	7.37	7.32	7.29	7.41	7.40	7.86	7.71	7.29	7.39	7.40
Inst. Min	5.80	5.84	5.75	5.78	5.89	5.84	5.84	5.82	5.80	5.78	5.75	5.83	5.80	5.84

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMHN1WNW220012

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.46	4.64	4.46	4.31	4.48	4.47	4.58	4.55	4.34	3.90	4.13	5.13	4.46	4.52
1:00	3.95	4.04	3.90	3.85	3.65	3.86	3.90	3.83	3.72	3.59	3.73	4.29	3.58	3.89
2:00	3.34	3.32	3.32	3.41	3.19	3.36	3.41	3.24	3.22	3.33	3.31	3.58	3.20	3.35
3:00	2.88	2.80	2.95	2.95	2.71	2.90	2.83	2.78	2.73	2.86	2.96	2.98	2.75	2.95
4:00	2.60	2.50	2.67	2.59	2.54	2.67	2.50	2.50	2.54	2.50	2.60	2.81	2.51	2.69
5:00	2.60	2.44	2.46	2.46	2.53	2.68	2.51	2.47	2.61	2.36	2.39	2.77	2.47	2.67
6:00	2.94	2.86	2.41	2.37	3.00	3.05	2.90	2.87	3.18	2.31	2.28	3.20	2.81	3.03
7:00	3.69	3.65	2.83	2.55	3.94	3.86	3.65	3.60	3.81	2.61	2.44	4.23	3.57	3.76
8:00	4.34	4.63	3.61	3.25	4.89	4.67	4.75	4.31	4.43	3.52	3.14	5.10	4.53	4.52
9:00	4.92	5.26	5.09	4.75	5.02	5.17	5.04	4.92	4.88	5.16	4.62	5.38	5.10	5.28
10:00	5.16	5.49	5.97	5.86	5.34	5.31	5.23	5.10	5.14	6.01	5.57	5.58	5.33	5.42
11:00	5.30	5.41	6.41	6.37	5.39	5.30	5.34	5.05	5.14	6.50	6.14	5.51	5.40	5.39
12:00	5.08	5.45	6.62	6.24	5.32	5.15	5.44	4.82	4.99	6.67	6.41	5.34	5.26	5.30
13:00	4.95	5.28	6.26	5.76	5.22	4.94	5.26	4.54	4.69	6.21	6.21	5.13	5.06	5.20
14:00	5.07	5.01	5.96	5.65	4.87	5.09	5.01	4.38	4.64	5.85	6.23	4.85	4.97	4.95
15:00	4.77	4.80	5.73	5.32	4.65	4.87	4.64	4.24	4.55	5.63	6.14	4.65	4.71	4.75
16:00	4.42	4.68	5.43	5.22	4.54	4.35	4.41	4.21	4.45	5.49	6.09	4.43	4.60	4.59
17:00	4.31	4.76	5.34	5.07	4.45	4.39	4.34	4.13	4.38	5.29	6.01	4.44	4.70	4.53
18:00	4.44	4.78	5.32	4.86	4.56	4.56	4.46	4.20	4.35	5.06	5.92	4.54	4.76	4.66
19:00	4.63	4.81	5.18	4.97	4.71	4.76	4.80	4.58	4.40	4.99	6.04	4.65	4.93	4.96
20:00	4.91	4.67	5.10	5.07	4.99	4.94	4.90	4.82	4.54	4.84	6.07	4.88	5.24	5.35
21:00	5.01	4.77	5.04	5.19	5.19	5.12	5.04	4.97	4.72	4.82	6.22	5.16	5.34	5.44
22:00	5.20	4.73	4.92	5.22	5.27	5.22	5.13	4.96	4.86	4.77	6.27	5.32	5.36	5.47
23:00	5.12	4.70	4.84	5.09	5.11	5.04	5.06	4.94	4.44	4.53	5.86	5.10	5.15	5.38
Average	4.34	4.39	4.66	4.52	4.40	4.41	4.38	4.17	4.20	4.53	4.87	4.54	4.41	4.50
Median	4.54	4.72	5.02	5.02	4.73	4.72	4.78	4.32	4.45	4.84	5.88	4.77	4.74	4.74
Max Hr. Mean	5.30	5.49	6.62	6.37	5.39	5.31	5.44	5.10	5.14	6.67	6.41	5.58	5.40	5.47
Min Hr. Mean	2.60	2.44	2.41	2.37	2.53	2.67	2.50	2.47	2.54	2.31	2.28	2.77	2.47	2.67
Inst. Max	5.44	5.56	6.70	6.48	5.45	5.38	5.46	5.22	5.21	6.76	6.59	5.61	5.44	5.53
Inst. Min	2.53	2.36	2.37	2.36	2.48	2.63	2.41	2.44	2.47	2.26	2.26	2.73	2.44	2.63

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 03
Address: Litchfield Line - North (at Laurel)
MH ID# SSMH3N1WNW220001

Date: 06/09/08
GPS: 33.353329N -112.213314W

Overview

Street Level

Meter Details

Meter Type	2150
Serial #	204K00870
Sensor Serial #	204M01676
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	30"	Horiz.	30"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole

Hydraulics:
Moderate to fast flow conditions.

Comments:
Elbow configuration

Photos
MH #SSMH3N1WNW220001
Site #03

Site ID (Night Photo)

Down Manhole

30” Influent

30” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

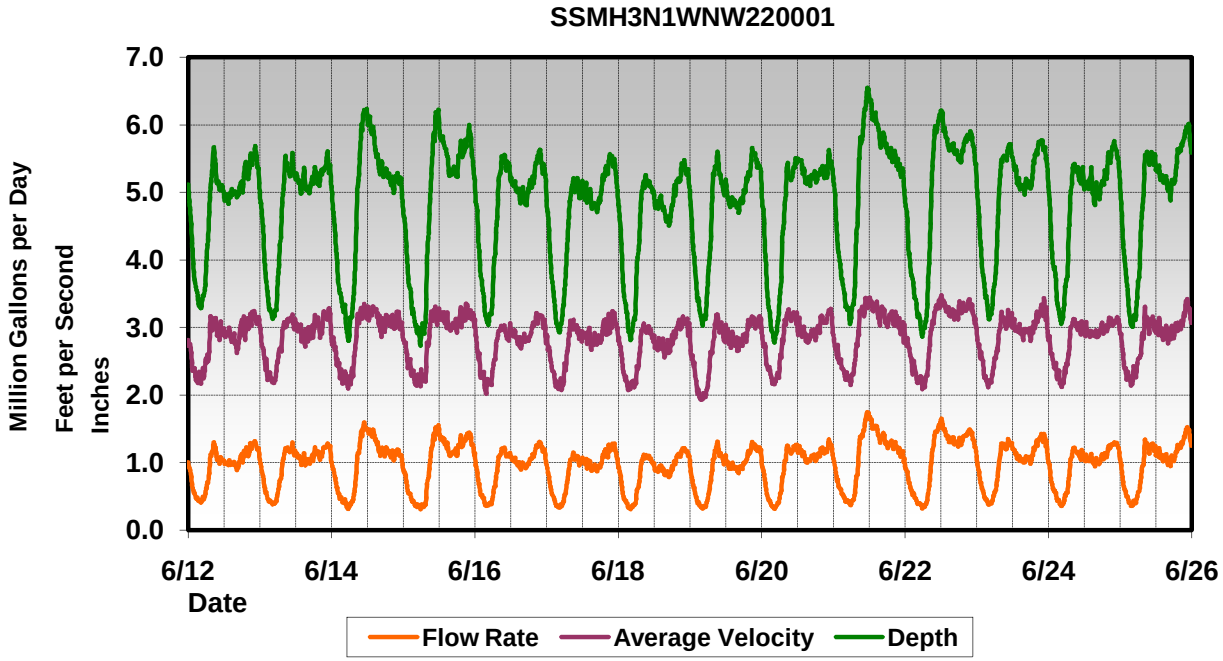
Site	**SSMH3N1WNW220001**
Address	**Litchfield Line - North**
Diameter	**30** Inches
GPS	**33.353329N -112.213314W**

Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.81
Maximum	6.54
Minimum	2.74
Max d/D	21.8%

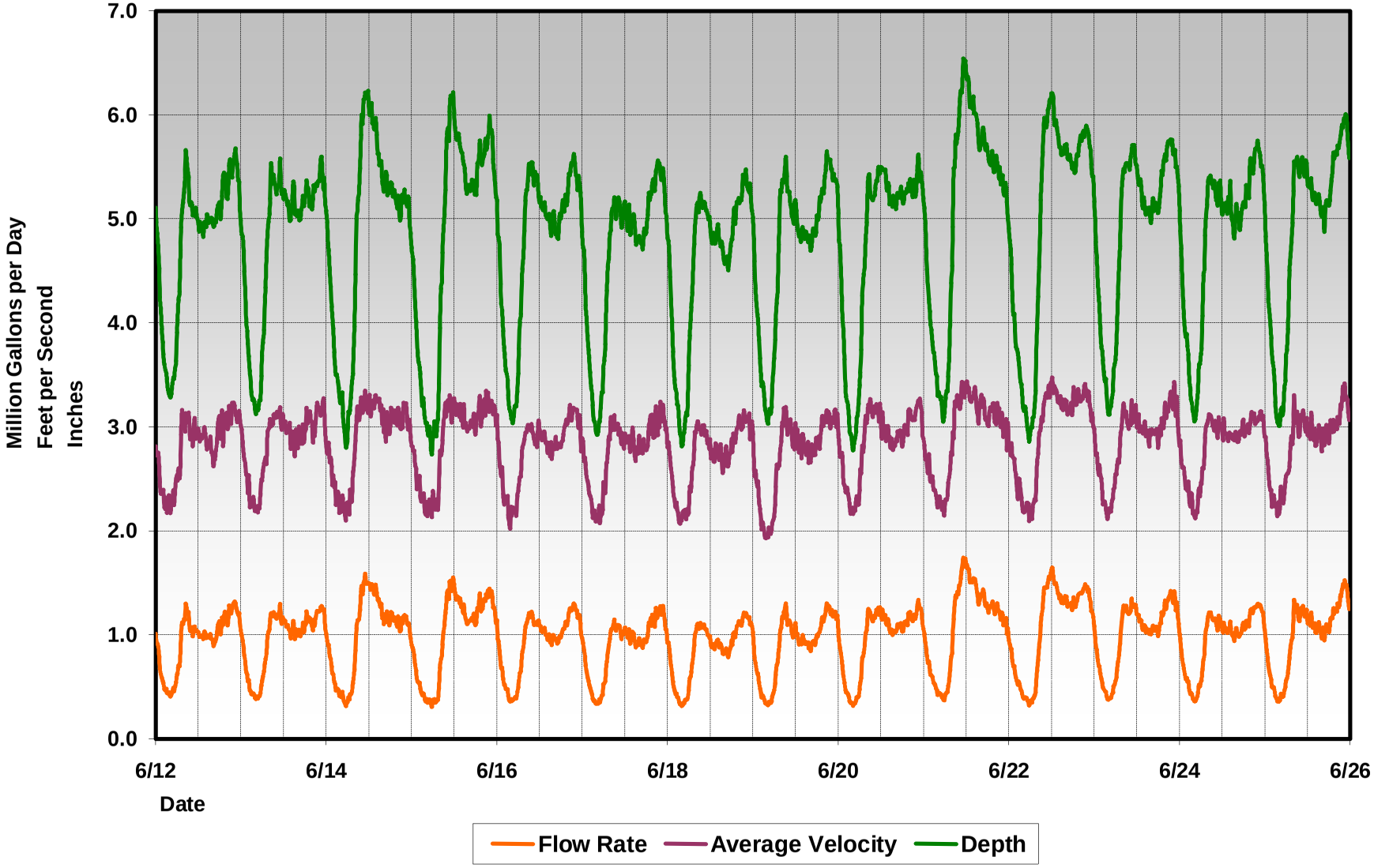
Flow velocity	
	Feet per Second
Average	2.84
Maximum	3.47
Minimum	1.93

Flow Rate	
	Million Gallons per Day
Average	0.97
Maximum	1.74
Minimum	0.31
Peak Factor	1.80



Flow Rate - Velocity - Depth

SSMH3N1WNW220001

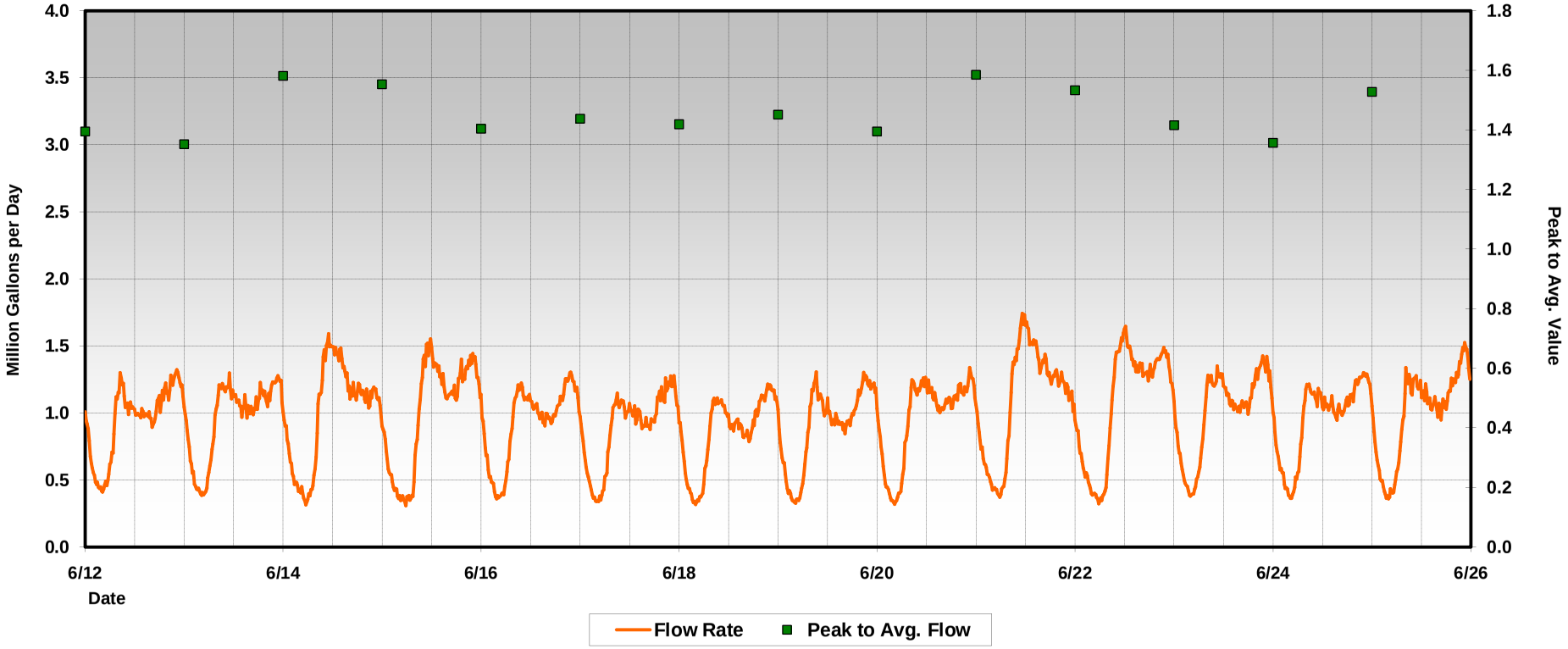


Peak to Average Flow Rate

Site ID SSMH3N1WNW220001

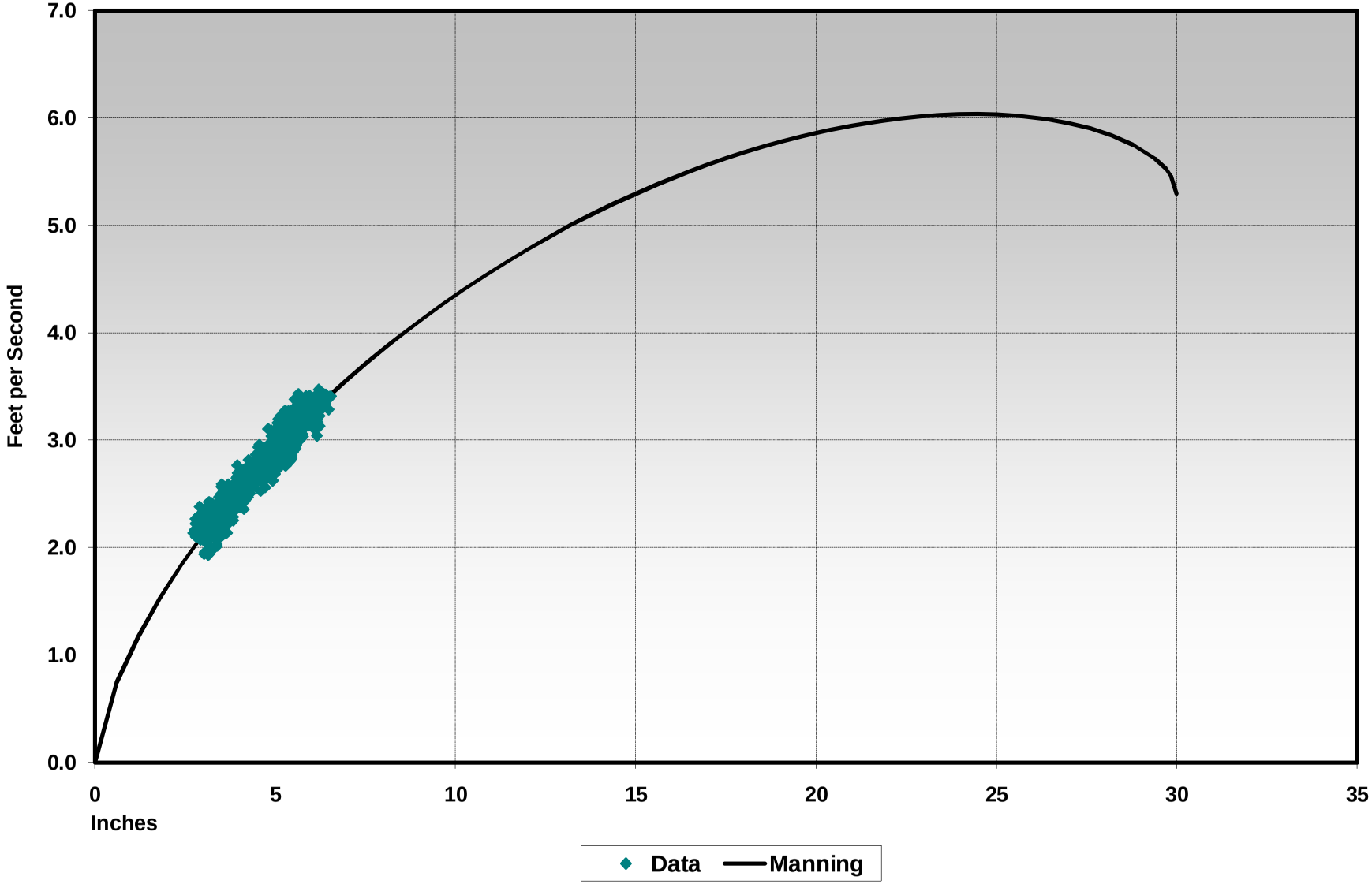
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.39	1.35	1.58	1.55	1.40	1.44	1.42	1.45	1.39	1.59	1.53	1.42	1.36	1.53



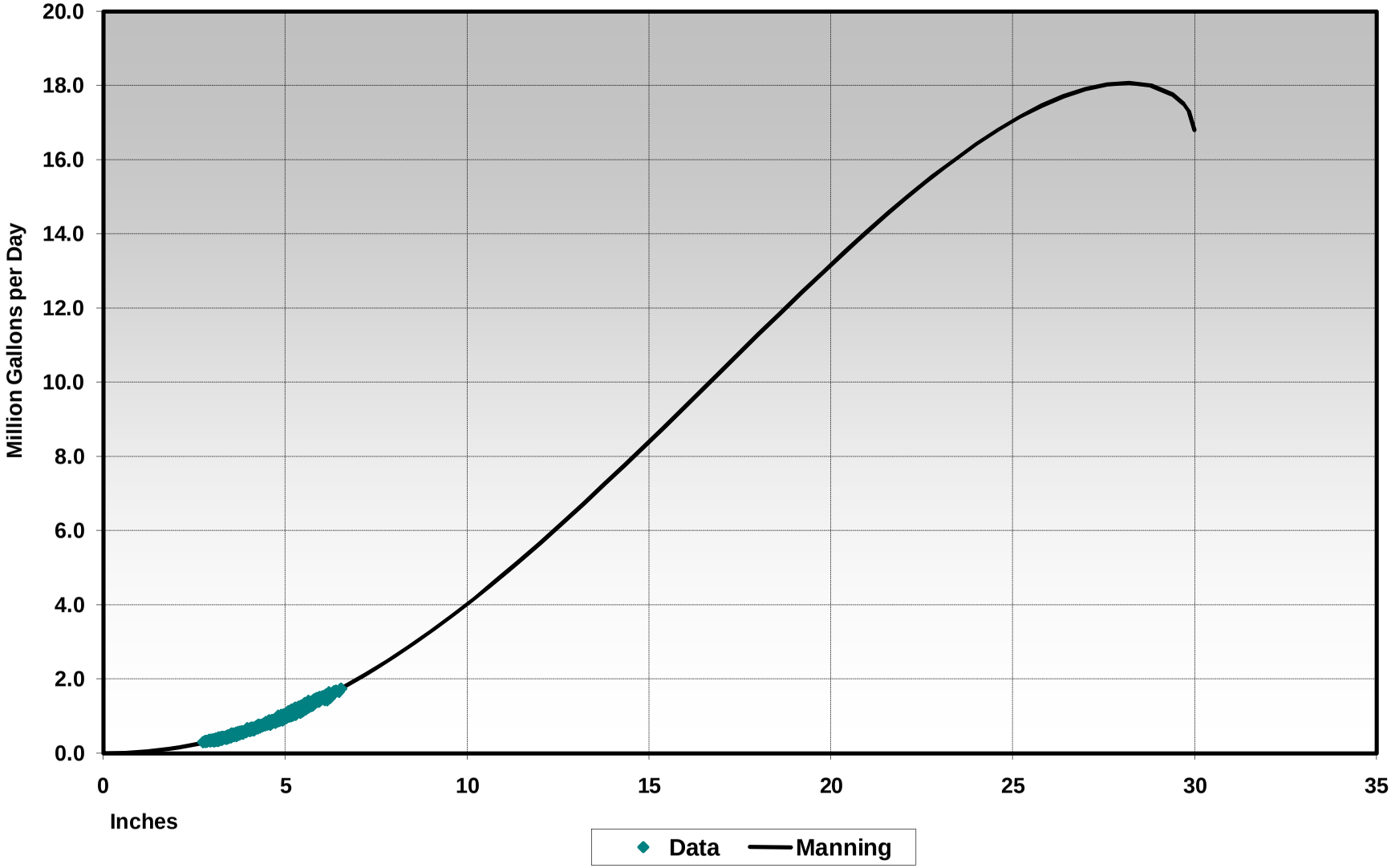
Velocity vs. Depth Scattergraph

SSMH3N1WNW220001



Flow Rate vs. Depth Scattergraph

SSMH3N1WNW220001



Flow Rate - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.94	0.96	0.94	0.86	0.97	0.88	0.88	0.85	0.92	0.96	0.90	0.95	0.90	0.91
1:00	0.67	0.70	0.72	0.63	0.67	0.62	0.60	0.62	0.65	0.73	0.70	0.69	0.65	0.63
2:00	0.51	0.51	0.54	0.50	0.50	0.47	0.44	0.44	0.45	0.59	0.55	0.52	0.54	0.49
3:00	0.45	0.43	0.46	0.42	0.40	0.37	0.36	0.36	0.36	0.50	0.48	0.43	0.42	0.39
4:00	0.43	0.39	0.42	0.36	0.38	0.35	0.34	0.34	0.33	0.43	0.40	0.39	0.37	0.40
5:00	0.50	0.44	0.34	0.35	0.41	0.40	0.38	0.39	0.40	0.40	0.36	0.48	0.47	0.44
6:00	0.66	0.63	0.39	0.37	0.59	0.58	0.58	0.58	0.60	0.43	0.36	0.64	0.64	0.62
7:00	1.02	0.90	0.50	0.40	0.87	0.86	0.86	0.88	0.89	0.63	0.45	0.96	0.98	0.90
8:00	1.22	1.15	0.93	0.79	1.12	1.06	1.07	1.16	1.18	1.07	0.82	1.24	1.20	1.23
9:00	1.15	1.19	1.24	1.15	1.20	1.08	1.09	1.21	1.17	1.39	1.24	1.23	1.15	1.20
10:00	1.05	1.19	1.47	1.42	1.13	1.08	1.07	1.12	1.19	1.53	1.46	1.27	1.10	1.26
11:00	1.05	1.19	1.52	1.50	1.12	1.00	1.01	1.00	1.23	1.71	1.55	1.28	1.15	1.20
12:00	1.00	1.12	1.48	1.40	1.06	1.02	0.92	1.02	1.19	1.65	1.58	1.18	1.06	1.13
13:00	0.99	1.07	1.44	1.35	1.04	0.98	0.90	0.93	1.14	1.52	1.46	1.10	1.05	1.13
14:00	0.99	1.05	1.39	1.27	0.99	1.00	0.93	0.95	1.08	1.52	1.36	1.07	1.06	1.05
15:00	0.98	1.01	1.26	1.14	0.94	0.90	0.86	0.91	1.03	1.36	1.34	1.03	0.98	1.07
16:00	0.93	1.02	1.15	1.14	0.97	0.92	0.84	0.90	1.06	1.39	1.32	1.05	1.02	1.01
17:00	1.04	1.05	1.15	1.15	0.96	0.93	0.83	0.94	1.10	1.32	1.29	1.06	1.04	1.07
18:00	1.10	1.14	1.19	1.18	1.03	1.00	0.97	1.01	1.07	1.25	1.30	1.06	1.09	1.11
19:00	1.16	1.14	1.14	1.30	1.10	1.14	1.04	1.11	1.14	1.29	1.36	1.22	1.13	1.22
20:00	1.18	1.09	1.10	1.31	1.21	1.14	1.12	1.22	1.18	1.24	1.41	1.31	1.23	1.26
21:00	1.25	1.21	1.12	1.39	1.27	1.20	1.17	1.25	1.17	1.21	1.46	1.39	1.27	1.37
22:00	1.30	1.25	1.16	1.40	1.23	1.24	1.19	1.20	1.28	1.16	1.42	1.36	1.29	1.49
23:00	1.19	1.20	1.06	1.21	1.12	1.11	1.12	1.19	1.21	1.10	1.23	1.21	1.21	1.36
Average	0.95	0.96	1.01	1.00	0.93	0.89	0.86	0.90	0.96	1.10	1.07	1.01	0.96	1.00
Median	1.01	1.05	1.13	1.15	1.00	0.97	0.92	0.96	1.10	1.23	1.29	1.09	1.05	1.09
Max Hr. Mean	1.30	1.25	1.52	1.50	1.27	1.24	1.19	1.25	1.28	1.71	1.58	1.39	1.29	1.49
Min Hr. Mean	0.43	0.39	0.34	0.35	0.38	0.35	0.34	0.34	0.33	0.40	0.36	0.39	0.37	0.39
Inst. Max	1.32	1.30	1.59	1.55	1.30	1.28	1.22	1.31	1.34	1.74	1.65	1.42	1.30	1.52
Inst. Min	0.41	0.39	0.32	0.31	0.36	0.34	0.32	0.33	0.32	0.37	0.32	0.38	0.36	0.36

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.76	2.90	2.81	2.79	2.87	2.78	2.78	2.68	2.81	2.78	2.79	2.82	2.74	2.80
1:00	2.46	2.60	2.61	2.52	2.52	2.52	2.47	2.41	2.59	2.62	2.68	2.58	2.54	2.46
2:00	2.30	2.35	2.42	2.41	2.30	2.31	2.25	2.11	2.38	2.47	2.45	2.35	2.40	2.27
3:00	2.27	2.28	2.31	2.29	2.15	2.14	2.11	1.97	2.24	2.35	2.37	2.20	2.28	2.23
4:00	2.23	2.20	2.29	2.20	2.21	2.15	2.15	1.98	2.20	2.27	2.19	2.19	2.16	2.28
5:00	2.37	2.33	2.18	2.22	2.23	2.15	2.17	2.04	2.30	2.23	2.22	2.36	2.30	2.35
6:00	2.53	2.60	2.27	2.27	2.47	2.48	2.35	2.36	2.59	2.29	2.18	2.60	2.53	2.55
7:00	2.94	2.82	2.43	2.30	2.81	2.80	2.74	2.66	2.91	2.58	2.33	2.86	2.91	2.80
8:00	3.07	3.04	2.96	2.78	2.98	3.03	3.00	3.02	3.14	2.95	2.83	3.14	3.10	3.11
9:00	3.03	3.09	3.14	3.12	3.00	3.02	2.97	3.08	3.17	3.23	3.09	3.05	3.02	3.01
10:00	2.92	3.12	3.21	3.24	2.90	2.97	2.97	3.03	3.18	3.28	3.29	3.10	2.99	3.12
11:00	2.97	3.09	3.21	3.19	2.91	2.87	2.87	2.85	3.14	3.38	3.35	3.11	3.03	3.03
12:00	2.92	3.01	3.21	3.20	2.92	2.90	2.77	2.92	3.00	3.37	3.41	3.03	2.96	2.96
13:00	2.93	3.00	3.24	3.16	2.92	2.84	2.75	2.80	2.93	3.26	3.32	2.97	2.91	3.00
14:00	2.86	2.88	3.27	3.10	2.82	2.88	2.77	2.85	2.90	3.32	3.24	2.98	2.92	2.88
15:00	2.83	2.82	3.17	3.00	2.77	2.74	2.68	2.75	2.82	3.13	3.22	2.90	2.91	2.93
16:00	2.69	2.90	3.03	3.02	2.83	2.82	2.72	2.77	2.88	3.26	3.19	2.95	2.89	2.88
17:00	2.93	2.90	3.04	3.03	2.82	2.81	2.69	2.79	2.94	3.12	3.17	2.95	2.97	2.95
18:00	3.04	3.04	3.13	3.05	2.87	2.85	2.86	2.85	2.92	3.08	3.28	2.91	2.98	2.98
19:00	2.99	3.12	3.09	3.17	3.03	3.06	2.93	3.00	3.01	3.20	3.28	3.06	2.98	3.01
20:00	3.09	2.95	3.08	3.17	3.13	2.98	3.05	3.10	3.12	3.09	3.28	3.16	3.10	3.03
21:00	3.13	3.16	3.08	3.27	3.14	2.98	3.06	3.08	3.09	3.09	3.35	3.27	3.07	3.17
22:00	3.17	3.14	3.18	3.21	3.15	3.15	3.08	3.05	3.22	3.03	3.29	3.27	3.09	3.34
23:00	3.10	3.17	2.99	3.13	2.96	3.02	3.03	3.11	3.13	2.97	3.09	3.09	3.09	3.19
Average	2.81	2.85	2.89	2.87	2.78	2.76	2.72	2.72	2.86	2.93	2.95	2.87	2.83	2.85
Median	2.90	2.97	3.04	3.02	2.85	2.86	2.79	2.81	2.93	3.06	3.17	2.97	2.94	2.93
Max Hr. Mean	3.17	3.17	3.27	3.27	3.15	3.15	3.08	3.11	3.22	3.38	3.41	3.27	3.10	3.34
Min Hr. Mean	2.23	2.20	2.18	2.20	2.15	2.14	2.11	1.97	2.20	2.23	2.18	2.19	2.16	2.23
Inst. Max	3.24	3.28	3.35	3.35	3.21	3.24	3.16	3.19	3.27	3.44	3.47	3.43	3.15	3.42
Inst. Min	2.17	2.18	2.10	2.14	2.03	2.08	2.07	1.93	2.17	2.15	2.10	2.12	2.12	2.14

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNW220001

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.92	4.84	4.87	4.60	4.89	4.68	4.67	4.69	4.78	4.98	4.74	4.89	4.78	4.77
1:00	4.21	4.19	4.28	3.95	4.15	3.96	3.89	4.03	3.96	4.31	4.09	4.19	4.03	4.06
2:00	3.67	3.61	3.68	3.52	3.63	3.47	3.34	3.49	3.29	3.86	3.72	3.67	3.71	3.58
3:00	3.41	3.28	3.41	3.20	3.27	3.08	3.03	3.24	2.97	3.58	3.44	3.36	3.25	3.11
4:00	3.33	3.17	3.23	2.99	3.07	2.97	2.88	3.10	2.83	3.30	3.18	3.16	3.10	3.10
5:00	3.53	3.29	2.89	2.87	3.23	3.23	3.14	3.30	3.09	3.16	2.96	3.44	3.46	3.28
6:00	4.12	3.91	3.08	2.95	3.84	3.79	3.91	3.93	3.73	3.28	3.00	3.93	4.00	3.91
7:00	4.96	4.70	3.48	3.11	4.61	4.59	4.63	4.83	4.56	3.89	3.33	4.88	4.88	4.72
8:00	5.47	5.28	4.63	4.34	5.27	5.03	5.09	5.34	5.27	5.12	4.40	5.46	5.39	5.47
9:00	5.30	5.38	5.44	5.20	5.50	5.10	5.18	5.43	5.21	5.79	5.51	5.53	5.34	5.51
10:00	5.10	5.31	6.06	5.87	5.42	5.16	5.13	5.20	5.28	6.15	5.92	5.61	5.20	5.56
11:00	5.06	5.36	6.20	6.18	5.36	5.00	5.04	5.04	5.43	6.49	6.10	5.62	5.30	5.48
12:00	4.94	5.23	6.08	5.87	5.15	5.05	4.84	5.02	5.48	6.35	6.12	5.40	5.09	5.33
13:00	4.90	5.10	5.91	5.76	5.10	4.95	4.81	4.83	5.40	6.11	5.89	5.23	5.14	5.28
14:00	4.99	5.16	5.76	5.59	5.03	5.00	4.86	4.87	5.24	6.06	5.70	5.11	5.15	5.18
15:00	4.99	5.11	5.49	5.33	4.93	4.80	4.72	4.83	5.18	5.83	5.66	5.08	4.90	5.17
16:00	4.97	5.02	5.33	5.29	4.94	4.79	4.60	4.78	5.19	5.78	5.63	5.10	5.04	5.03
17:00	5.08	5.15	5.29	5.32	4.92	4.83	4.61	4.88	5.26	5.72	5.56	5.12	5.03	5.15
18:00	5.13	5.28	5.31	5.40	5.10	5.04	4.92	5.06	5.19	5.58	5.48	5.18	5.19	5.24
19:00	5.41	5.20	5.22	5.61	5.15	5.26	5.08	5.23	5.29	5.56	5.64	5.51	5.31	5.57
20:00	5.32	5.22	5.11	5.64	5.39	5.35	5.18	5.45	5.32	5.53	5.79	5.66	5.49	5.67
21:00	5.49	5.34	5.17	5.75	5.57	5.52	5.35	5.58	5.29	5.43	5.85	5.74	5.65	5.82
22:00	5.60	5.50	5.19	5.87	5.41	5.44	5.36	5.44	5.48	5.33	5.80	5.67	5.67	5.95
23:00	5.35	5.31	5.06	5.40	5.29	5.17	5.22	5.35	5.38	5.21	5.50	5.43	5.44	5.77
Average	4.80	4.79	4.84	4.82	4.76	4.64	4.56	4.71	4.75	5.10	4.96	4.91	4.81	4.90
Median	5.00	5.13	5.19	5.29	5.06	4.90	4.80	4.90	5.21	5.50	5.58	5.16	5.12	5.20
Max Hr. Mean	5.60	5.50	6.20	6.18	5.57	5.52	5.36	5.58	5.48	6.49	6.12	5.74	5.67	5.95
Min Hr. Mean	3.33	3.17	2.89	2.87	3.07	2.97	2.88	3.10	2.83	3.16	2.96	3.16	3.10	3.10
Inst. Max	5.68	5.60	6.23	6.22	5.63	5.56	5.48	5.65	5.62	6.54	6.21	5.77	5.75	6.01
Inst. Min	3.29	3.13	2.81	2.74	3.04	2.93	2.82	3.03	2.78	3.06	2.86	3.12	3.06	3.01

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 04**	**Date:**	**06/11/08**
Address:	**N Reems Road S of Waddell Road**	**GPS:**	**33.363319N -112.233798W**
MH ID#	**Alternate Location**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204M01456**
Sensor Serial #	**204M01442**
Telemetry	**None**
Sample Rate	**5 min**

Down Manhole

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert. 27" Horiz. 27"**
Laterals	**0**
Pipe Material	**PVC**
Surcharge Evidence	**No**
Height Above Crown (in)	**0**
Infiltration	**No**
Silt	**No**
Debris	**Yes - toilet paper**
Grease	**No**
Pests	**No**

Hydraulics:
Fast flow conditions.

Comments:
Original site buried by road construction. No install possible.
Alternate site installation.

Photos
MH # ALTERNATE LOCATION
Site #04

Site ID

Down Manhole

27” Influent

27” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

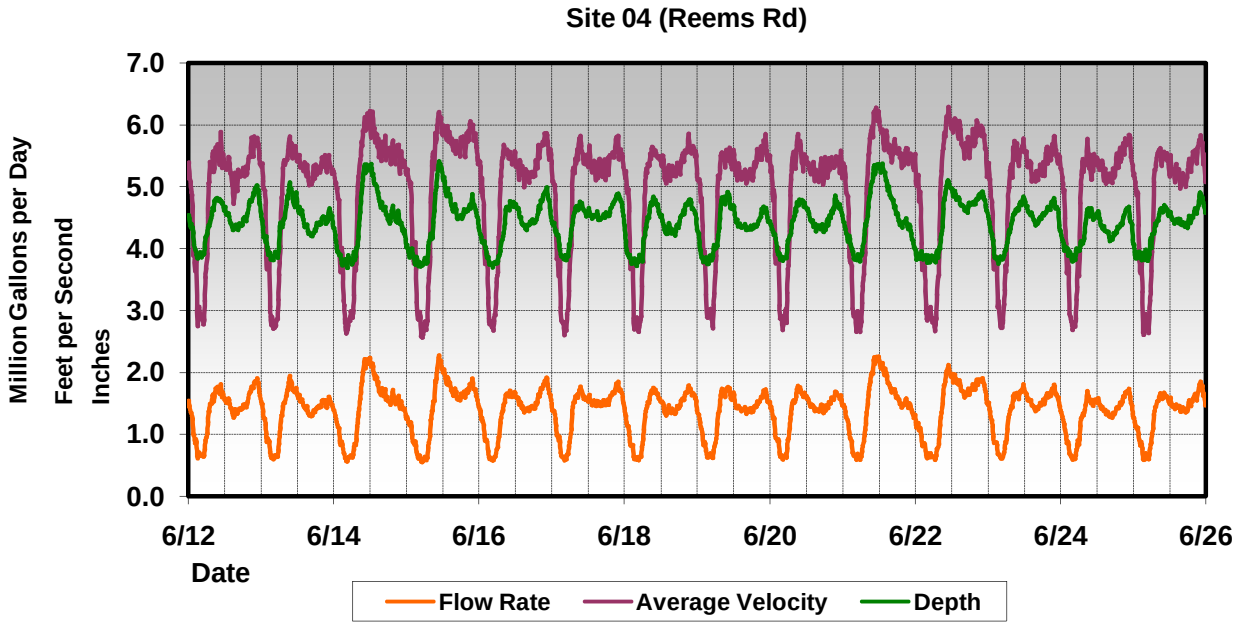
Site	**Site 04 (Reems Rd)**	
Address	**Reems Rd S of Waddell**	
Diameter	**27**	Inches
GPS	**33.363319N -112.233798W**	

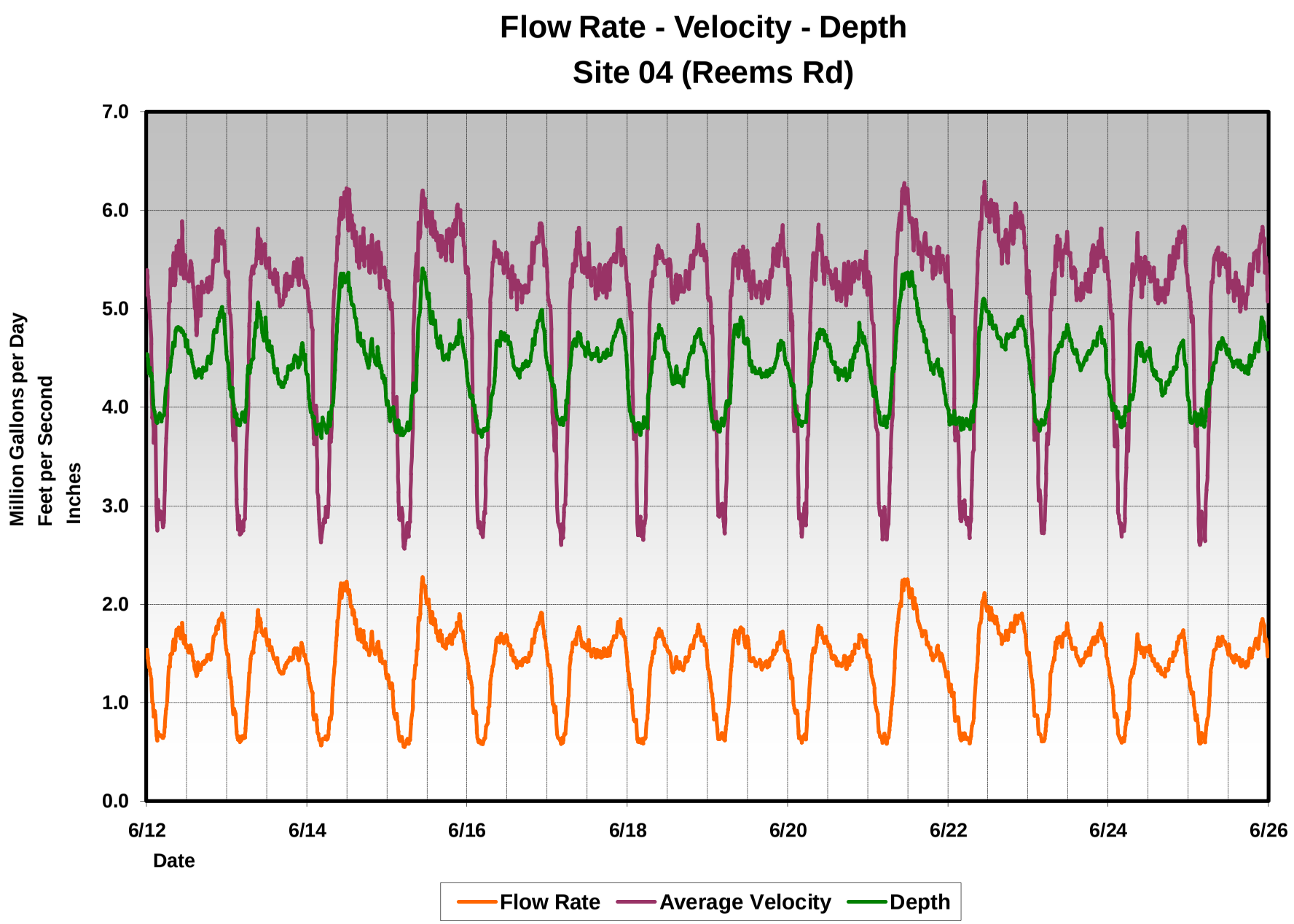
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.41
Maximum	5.41
Minimum	3.69
Max d/D	20.0%

Flow velocity	
	Feet per Second
Average	4.96
Maximum	6.29
Minimum	2.57

Flow Rate	
	Million Gallons per Day
Average	1.39
Maximum	2.28
Minimum	0.55
Peak Factor	1.64



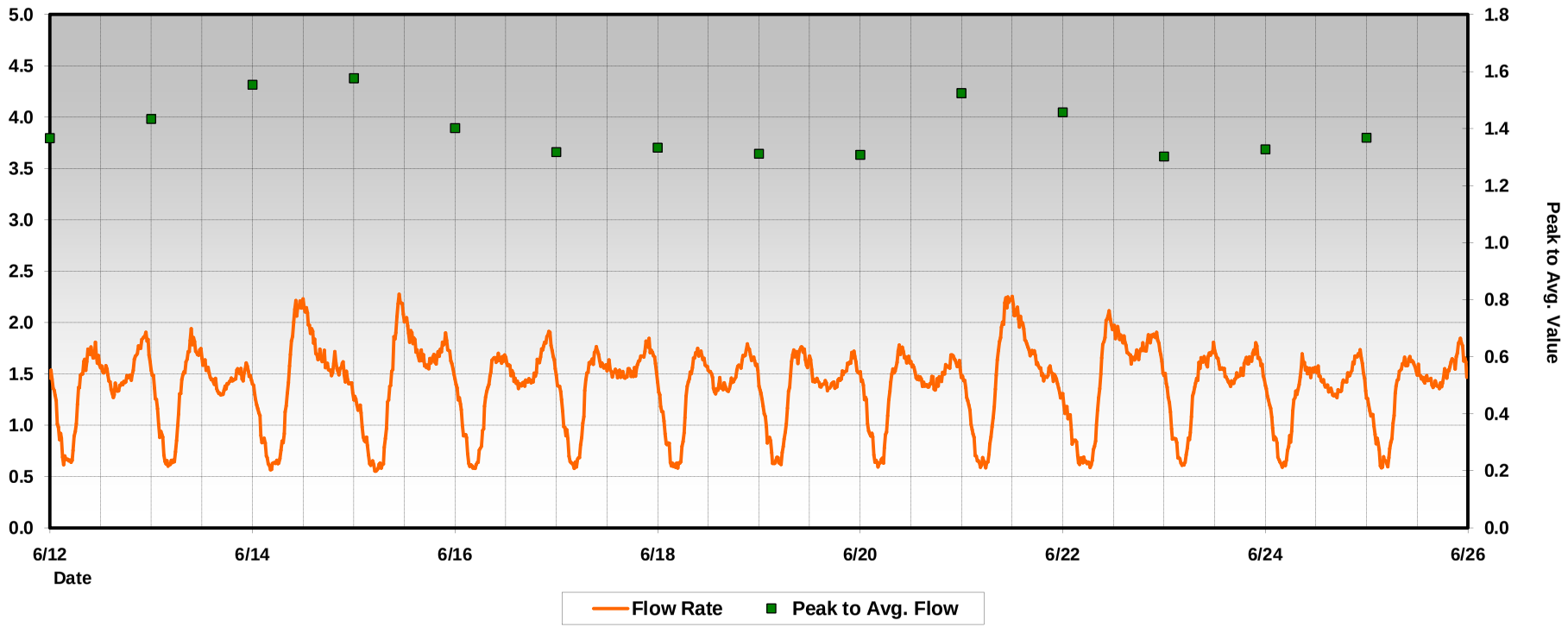

Flow Rate - Velocity - Depth
Site 04 (Reems Rd)
Million Gallons per Day
Feet per Second
Inches
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

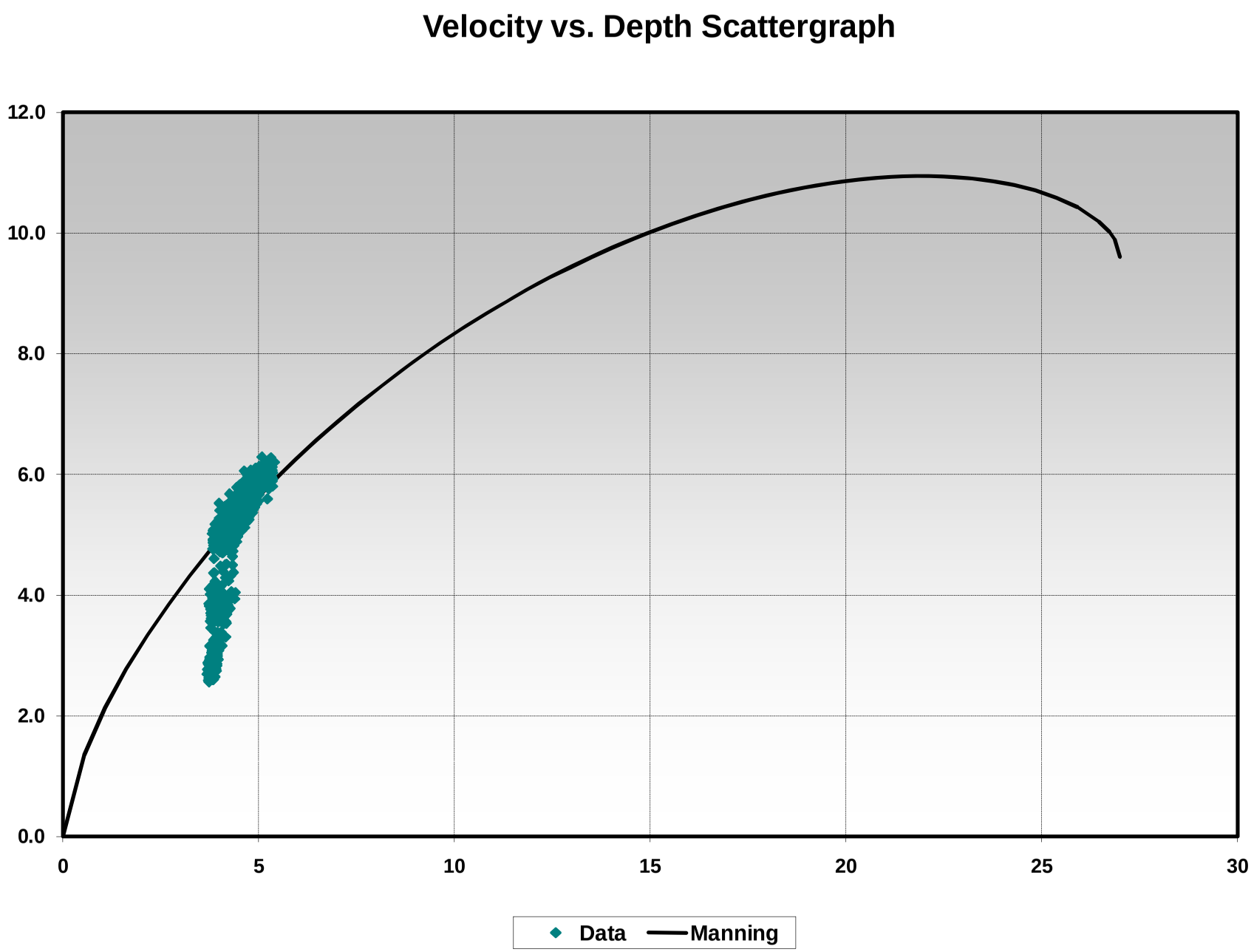
Peak to Average Flow Rate

Site ID Site 04 (Reems Rd)

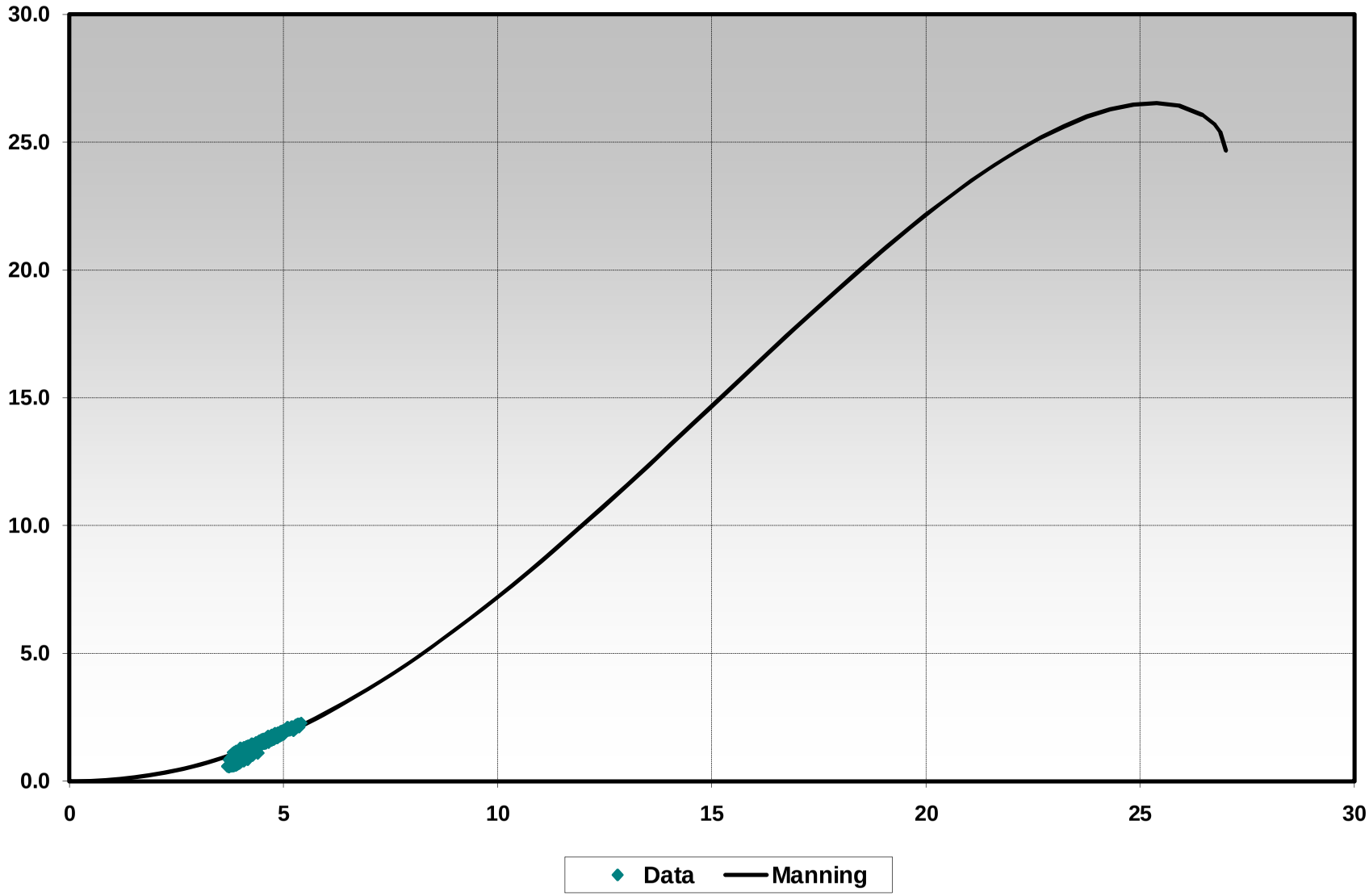
Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.37	1.43	1.55	1.58	1.40	1.32	1.33	1.31	1.31	1.52	1.46	1.30	1.33	1.37




Velocity vs. Depth Scattergraph
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
Data
Manning

Flow Rate vs. Depth Scattergraph



Flow Rate - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.45	1.47	1.33	1.25	1.36	1.41	1.30	1.32	1.44	1.45	1.20	1.44	1.32	1.21
1:00	1.22	1.17	1.14	1.15	1.15	1.17	1.05	1.09	1.20	1.27	1.11	1.15	1.10	1.07
2:00	0.91	0.90	0.86	0.89	0.90	0.93	0.82	0.85	0.92	1.01	0.87	0.87	0.86	0.86
3:00	0.67	0.66	0.71	0.76	0.64	0.65	0.62	0.65	0.72	0.73	0.76	0.72	0.65	0.64
4:00	0.66	0.62	0.59	0.63	0.59	0.61	0.61	0.67	0.62	0.62	0.65	0.62	0.61	0.66
5:00	0.74	0.67	0.64	0.56	0.66	0.71	0.68	0.69	0.69	0.64	0.65	0.75	0.78	0.72
6:00	1.13	1.07	0.67	0.61	0.87	1.08	1.03	0.99	1.05	0.71	0.62	1.04	1.04	1.07
7:00	1.46	1.44	0.93	0.81	1.29	1.52	1.44	1.45	1.45	1.03	0.77	1.39	1.31	1.45
8:00	1.60	1.62	1.37	1.31	1.51	1.61	1.59	1.69	1.55	1.55	1.19	1.57	1.53	1.57
9:00	1.72	1.82	1.84	1.69	1.64	1.73	1.71	1.69	1.73	1.91	1.69	1.64	1.58	1.60
10:00	1.70	1.77	2.14	2.10	1.65	1.62	1.69	1.74	1.70	2.14	1.99	1.64	1.51	1.64
11:00	1.64	1.71	2.16	2.16	1.64	1.58	1.60	1.60	1.63	2.22	2.02	1.73	1.55	1.58
12:00	1.54	1.62	2.16	2.01	1.61	1.57	1.52	1.57	1.59	2.14	1.91	1.68	1.53	1.51
13:00	1.54	1.54	1.98	1.88	1.52	1.51	1.36	1.44	1.48	2.07	1.89	1.56	1.44	1.44
14:00	1.38	1.44	1.87	1.80	1.43	1.51	1.39	1.40	1.44	1.99	1.83	1.51	1.38	1.46
15:00	1.33	1.38	1.67	1.67	1.38	1.51	1.37	1.41	1.40	1.80	1.72	1.41	1.34	1.41
16:00	1.36	1.30	1.66	1.66	1.41	1.47	1.35	1.37	1.39	1.71	1.65	1.42	1.29	1.40
17:00	1.41	1.34	1.62	1.57	1.44	1.53	1.41	1.40	1.41	1.67	1.68	1.48	1.32	1.38
18:00	1.46	1.42	1.52	1.64	1.44	1.51	1.47	1.39	1.42	1.58	1.71	1.51	1.40	1.48
19:00	1.49	1.45	1.61	1.64	1.57	1.60	1.57	1.47	1.47	1.47	1.75	1.62	1.46	1.52
20:00	1.68	1.51	1.53	1.71	1.69	1.67	1.67	1.52	1.56	1.50	1.84	1.63	1.54	1.63
21:00	1.78	1.48	1.57	1.82	1.81	1.77	1.75	1.61	1.62	1.51	1.87	1.73	1.65	1.68
22:00	1.87	1.56	1.45	1.75	1.87	1.75	1.66	1.69	1.64	1.46	1.85	1.68	1.69	1.81
23:00	1.74	1.48	1.39	1.57	1.65	1.61	1.58	1.54	1.58	1.31	1.64	1.52	1.47	1.59
Average	1.39	1.35	1.43	1.44	1.36	1.40	1.34	1.34	1.36	1.48	1.45	1.39	1.31	1.35
Median	1.48	1.45	1.53	1.61	1.44	1.52	1.44	1.42	1.46	1.49	1.69	1.49	1.39	1.45
Max Hr. Mean	1.87	1.82	2.16	2.16	1.87	1.77	1.75	1.74	1.73	2.22	2.02	1.73	1.69	1.81
Min Hr. Mean	0.66	0.62	0.59	0.56	0.59	0.61	0.61	0.65	0.62	0.62	0.62	0.62	0.61	0.64
Inst. Max	1.91	1.94	2.23	2.28	1.91	1.85	1.79	1.76	1.78	2.25	2.12	1.81	1.74	1.85
Inst. Min	0.62	0.60	0.57	0.55	0.58	0.58	0.58	0.62	0.59	0.59	0.59	0.61	0.59	0.59

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.19	5.28	5.15	5.22	5.26	5.15	5.17	5.13	5.33	5.26	5.18	5.21	5.19	5.15
1:00	4.58	4.64	4.89	4.97	4.68	4.50	4.62	4.74	4.63	4.94	4.94	4.50	4.60	4.77
2:00	3.85	3.84	3.83	3.90	3.85	3.75	3.74	3.84	3.86	4.01	3.83	3.82	3.69	3.77
3:00	2.95	2.91	3.24	3.44	2.92	2.87	2.78	2.99	3.18	3.16	3.35	3.25	2.87	2.81
4:00	2.90	2.75	2.71	2.92	2.74	2.72	2.77	2.96	2.79	2.80	2.94	2.76	2.75	2.87
5:00	3.08	2.91	2.88	2.61	3.04	3.07	2.97	2.98	3.02	2.83	2.90	3.25	3.32	3.02
6:00	4.29	4.05	3.01	2.78	3.90	4.16	4.23	4.13	4.14	3.03	2.79	4.21	4.34	4.23
7:00	5.26	5.24	4.01	3.39	5.26	5.31	5.27	5.27	5.34	3.93	3.31	5.23	5.31	5.35
8:00	5.40	5.42	5.19	5.13	5.57	5.46	5.42	5.51	5.38	5.30	4.82	5.49	5.49	5.55
9:00	5.57	5.63	5.70	5.61	5.54	5.73	5.59	5.49	5.69	5.86	5.71	5.60	5.45	5.46
10:00	5.55	5.62	6.01	6.01	5.51	5.49	5.55	5.54	5.56	6.09	6.02	5.49	5.24	5.52
11:00	5.46	5.59	6.06	6.04	5.47	5.47	5.48	5.40	5.42	6.19	6.10	5.65	5.44	5.46
12:00	5.30	5.46	6.05	5.93	5.41	5.43	5.44	5.42	5.41	6.01	5.99	5.56	5.38	5.30
13:00	5.40	5.34	5.89	5.88	5.30	5.31	5.18	5.26	5.28	5.79	6.03	5.36	5.34	5.20
14:00	5.11	5.31	5.78	5.78	5.25	5.28	5.22	5.18	5.25	5.87	5.93	5.26	5.22	5.23
15:00	4.94	5.22	5.49	5.67	5.18	5.32	5.22	5.23	5.24	5.63	5.73	5.14	5.11	5.12
16:00	5.09	5.05	5.60	5.65	5.18	5.21	5.22	5.13	5.19	5.53	5.62	5.18	5.15	5.13
17:00	5.20	5.18	5.62	5.58	5.20	5.35	5.27	5.24	5.26	5.67	5.67	5.25	5.18	5.11
18:00	5.24	5.27	5.52	5.77	5.24	5.27	5.28	5.18	5.31	5.59	5.66	5.25	5.36	5.37
19:00	5.26	5.28	5.54	5.62	5.44	5.49	5.47	5.43	5.29	5.46	5.77	5.54	5.43	5.41
20:00	5.50	5.42	5.47	5.81	5.62	5.51	5.57	5.48	5.40	5.42	5.95	5.51	5.59	5.57
21:00	5.67	5.35	5.56	6.00	5.75	5.67	5.71	5.54	5.37	5.55	5.94	5.65	5.67	5.61
22:00	5.72	5.42	5.37	5.84	5.81	5.62	5.58	5.72	5.45	5.50	5.86	5.62	5.78	5.74
23:00	5.57	5.28	5.34	5.53	5.54	5.46	5.53	5.49	5.37	5.36	5.49	5.46	5.49	5.35
Average	4.92	4.89	5.00	5.04	4.94	4.94	4.93	4.93	4.92	5.03	5.06	4.97	4.93	4.92
Median	5.24	5.29	5.43	5.60	5.31	5.34	5.30	5.25	5.28	5.51	5.66	5.33	5.29	5.27
Max Hr. Mean	5.72	5.63	6.06	6.04	5.81	5.73	5.71	5.72	5.69	6.19	6.10	5.65	5.78	5.74
Min Hr. Mean	2.90	2.75	2.71	2.61	2.74	2.72	2.77	2.96	2.79	2.80	2.79	2.76	2.75	2.81
Inst. Max	5.89	5.81	6.22	6.20	5.87	5.82	5.86	5.85	5.85	6.28	6.29	5.81	5.83	5.83
Inst. Min	2.75	2.71	2.63	2.57	2.68	2.60	2.65	2.73	2.69	2.66	2.67	2.72	2.69	2.60

All Values in Feet per Second

Depth - Tabular Output

Site ID Site 04 (Reems Rd)

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.47	4.46	4.25	4.01	4.25	4.41	4.17	4.23	4.38	4.44	3.93	4.44	4.19	3.98
1:00	4.33	4.17	3.96	3.94	4.11	4.27	3.90	3.91	4.24	4.22	3.85	4.20	4.02	3.86
2:00	3.98	3.98	3.85	3.89	3.96	4.11	3.79	3.82	4.02	4.15	3.87	3.89	3.95	3.88
3:00	3.87	3.87	3.78	3.80	3.79	3.88	3.82	3.78	3.89	3.94	3.87	3.81	3.89	3.87
4:00	3.89	3.88	3.79	3.74	3.73	3.84	3.78	3.85	3.84	3.82	3.82	3.84	3.84	3.90
5:00	4.01	3.92	3.82	3.74	3.78	3.93	3.86	3.94	3.89	3.85	3.86	3.92	3.96	4.00
6:00	4.29	4.27	3.83	3.80	3.83	4.23	4.07	4.03	4.17	3.94	3.81	4.10	4.03	4.18
7:00	4.46	4.43	3.93	4.01	4.08	4.55	4.41	4.42	4.38	4.28	3.93	4.32	4.11	4.38
8:00	4.67	4.69	4.30	4.20	4.37	4.65	4.64	4.78	4.58	4.62	4.10	4.54	4.46	4.51
9:00	4.80	4.94	4.95	4.72	4.66	4.72	4.76	4.79	4.75	4.97	4.65	4.62	4.60	4.62
10:00	4.78	4.88	5.30	5.23	4.70	4.66	4.75	4.87	4.76	5.24	5.03	4.68	4.56	4.67
11:00	4.71	4.77	5.31	5.32	4.71	4.57	4.61	4.66	4.72	5.33	5.03	4.76	4.53	4.58
12:00	4.61	4.66	5.30	5.12	4.67	4.58	4.48	4.59	4.63	5.30	4.91	4.73	4.53	4.54
13:00	4.53	4.57	5.10	4.92	4.57	4.52	4.30	4.41	4.48	5.31	4.85	4.61	4.38	4.45
14:00	4.37	4.40	4.96	4.82	4.39	4.54	4.32	4.37	4.41	5.12	4.79	4.56	4.32	4.47
15:00	4.36	4.32	4.74	4.64	4.34	4.52	4.29	4.36	4.33	4.92	4.70	4.43	4.27	4.43
16:00	4.34	4.24	4.67	4.62	4.40	4.49	4.24	4.33	4.35	4.80	4.63	4.42	4.15	4.40
17:00	4.39	4.25	4.58	4.50	4.44	4.54	4.34	4.34	4.35	4.65	4.66	4.50	4.21	4.38
18:00	4.47	4.36	4.44	4.52	4.43	4.55	4.47	4.35	4.35	4.50	4.72	4.56	4.28	4.43
19:00	4.51	4.41	4.60	4.61	4.57	4.61	4.57	4.37	4.46	4.37	4.73	4.62	4.36	4.50
20:00	4.75	4.47	4.48	4.64	4.71	4.74	4.69	4.45	4.57	4.44	4.80	4.66	4.42	4.63
21:00	4.85	4.46	4.51	4.74	4.86	4.83	4.77	4.59	4.73	4.39	4.87	4.77	4.60	4.69
22:00	4.99	4.56	4.37	4.70	4.93	4.83	4.67	4.65	4.71	4.32	4.86	4.69	4.62	4.87
23:00	4.83	4.50	4.25	4.52	4.67	4.65	4.55	4.49	4.64	4.08	4.68	4.47	4.35	4.67
Average	4.47	4.39	4.46	4.45	4.37	4.47	4.34	4.35	4.40	4.54	4.46	4.42	4.28	4.37
Median	4.48	4.41	4.45	4.54	4.42	4.54	4.38	4.37	4.44	4.43	4.70	4.54	4.28	4.46
Max Hr. Mean	4.99	4.94	5.31	5.32	4.93	4.83	4.77	4.87	4.76	5.33	5.03	4.77	4.62	4.87
Min Hr. Mean	3.87	3.87	3.78	3.74	3.73	3.84	3.78	3.78	3.84	3.82	3.81	3.81	3.84	3.86
Inst. Max	5.02	5.06	5.36	5.41	4.99	4.89	4.84	4.91	4.85	5.37	5.10	4.84	4.68	4.91
Inst. Min	3.84	3.82	3.69	3.72	3.70	3.82	3.72	3.75	3.81	3.80	3.77	3.76	3.80	3.80

All Values in Inches

FLOW SERVICES GROUP

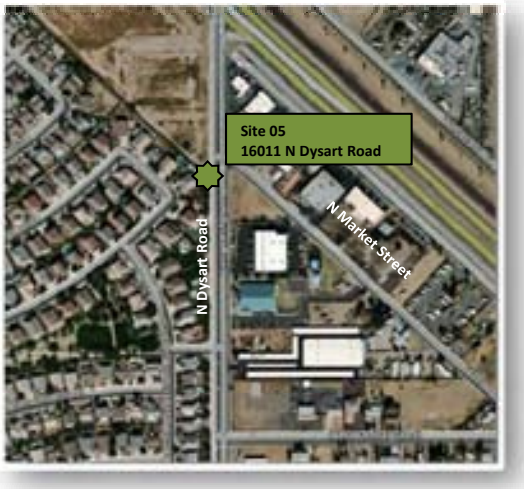
Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 05
Address: 16011 N Dysart Road
MH ID# SSMH3N1WSW020046

Date: 06/10/08
GPS: 33.374960N -112.203199W

Overview



Street Level

Meter Details

Meter Type 2150
Serial # 201D01151
Sensor Serial # 205E00560
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

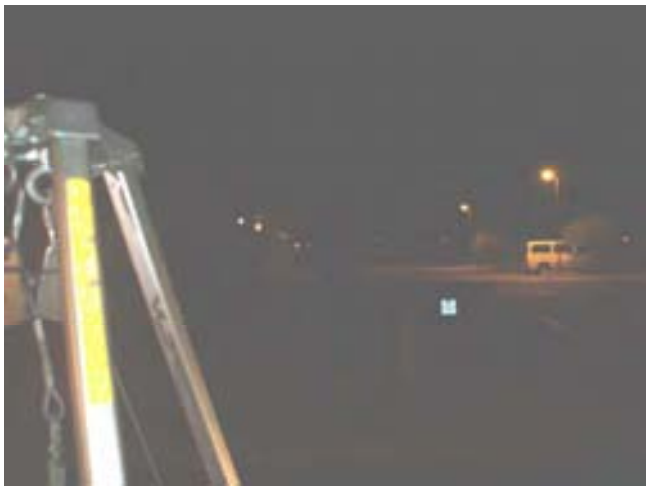
Pipe Size (in) Vert. 12" Horiz. 12"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Down Manhole

Hydraulics:
Low flow conditions.

Comments:
Swirling prevents effluent readings.

Photos
MH #SSMH3N1WSW020046
Site #05


Site ID (Night Photo)

Down Manhole

12” Influent

12” Effluent

6” Drop In (Dry)

MANHOLE COVER TOP

Photos
MH #SSMH3N1WSW020046
Site #05

Manhole Cover Bottom

Location Summary

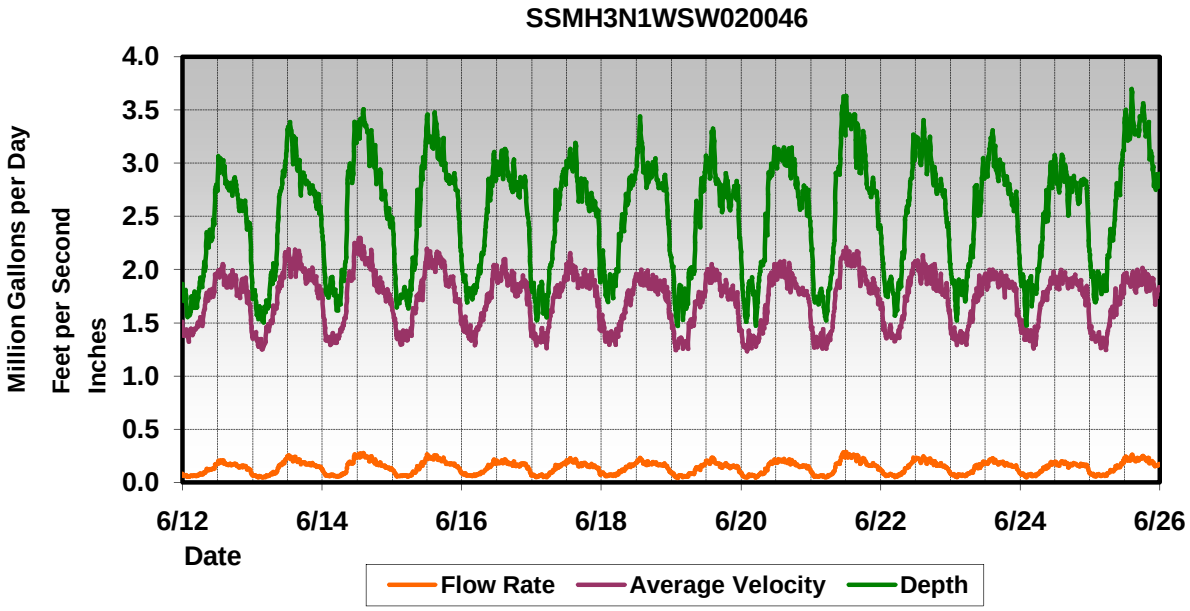
Site	**SSMH3N1WSW020046**	
Address	**16011 N Dysart Road**	
Diameter	**12**	Inches
GPS	**33.374960N**	**-112.203199W**

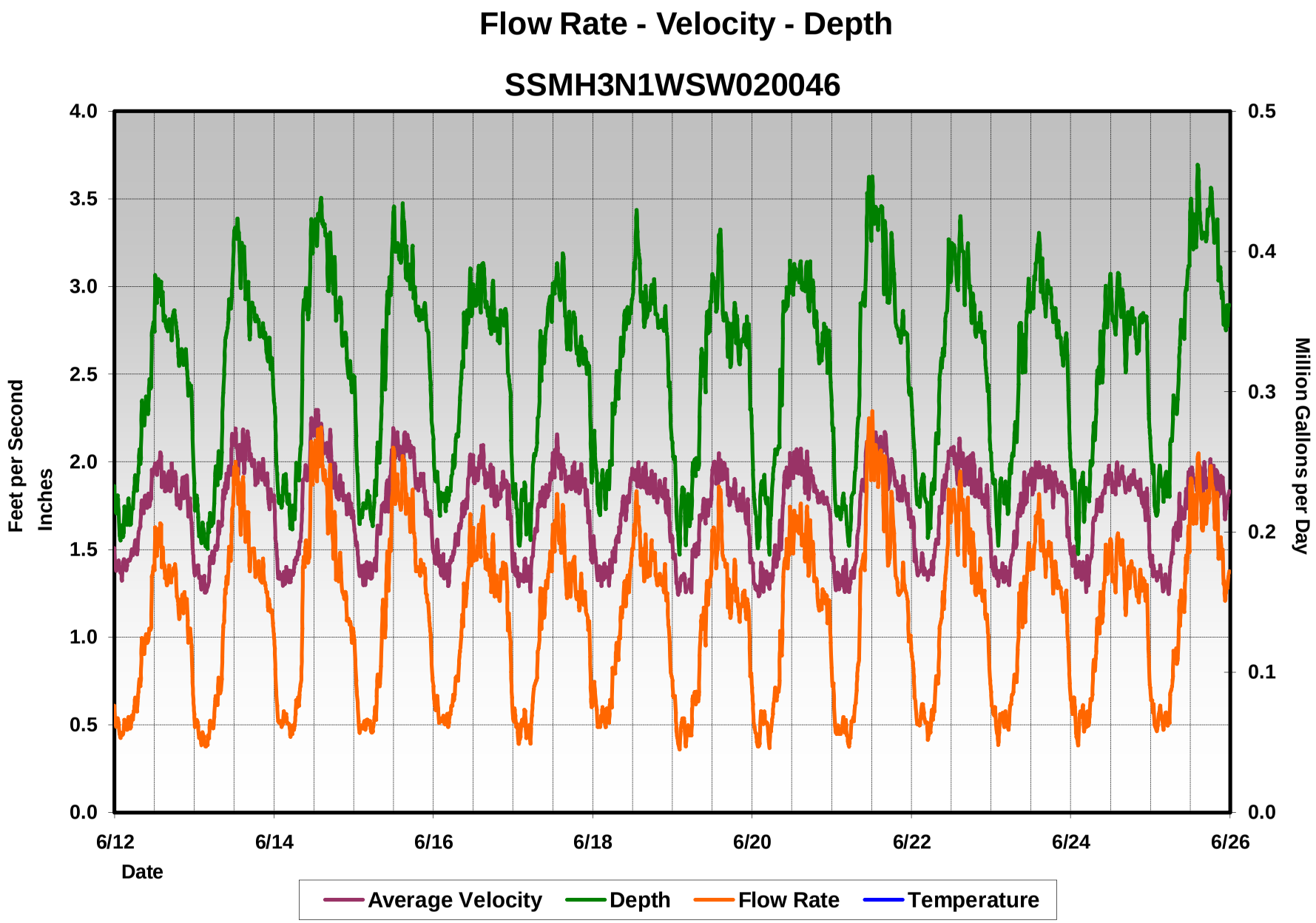
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	2.52
Maximum	3.69
Minimum	1.47
Max d/D	30.8%

Flow velocity	
	Feet per Second
Average	1.72
Maximum	2.30
Minimum	1.23

Flow Rate	
	Million Gallons per Day
Average	0.14
Maximum	0.29
Minimum	0.05
Peak Factor	2.03



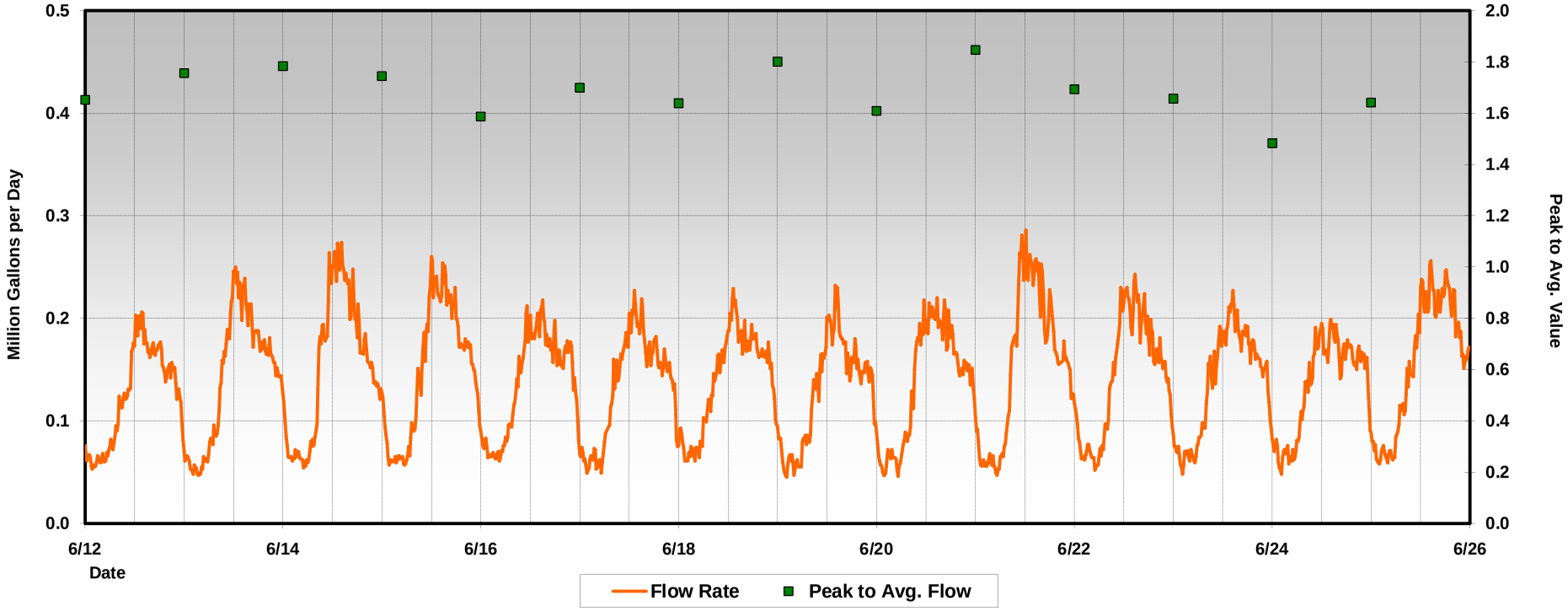

Flow Rate - Velocity - Depth
SSMH3N1WSW020046
Feet per Second
Inches
Million Gallons per Day
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.5
0.4
0.3
0.2
0.1
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate
Temperature

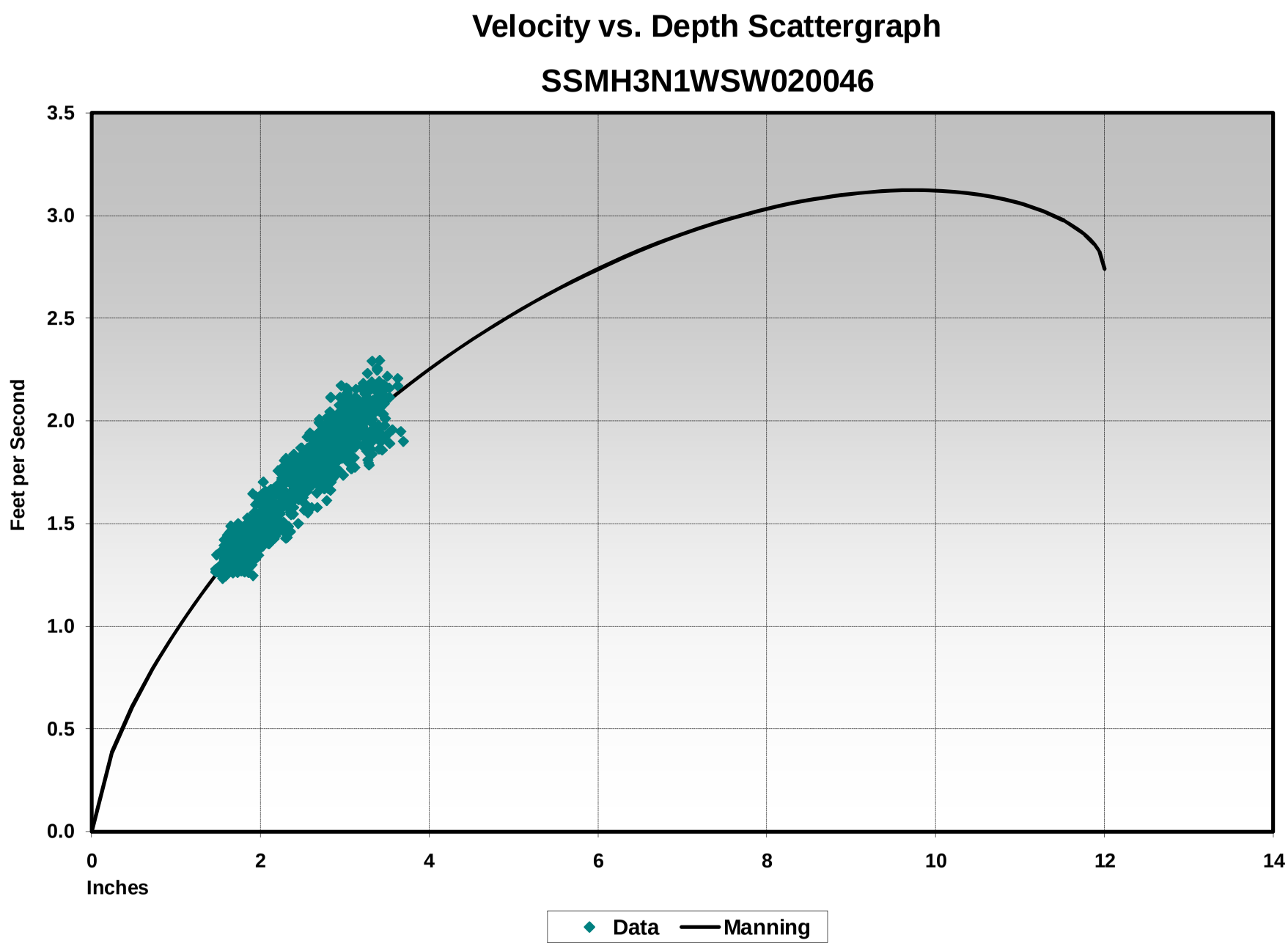
Peak to Average Flow Rate

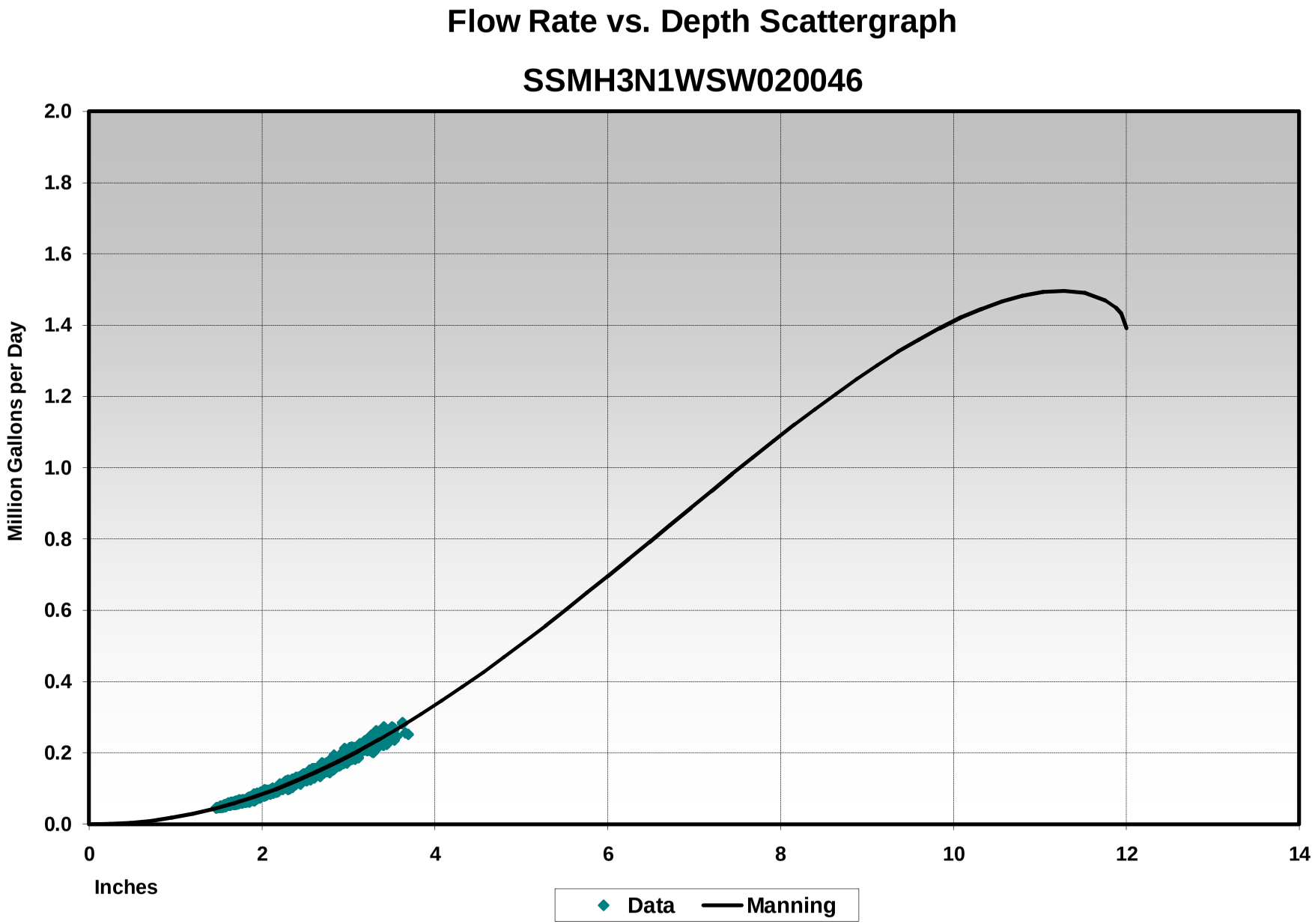
Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.65	1.76	1.78	1.75	1.59	1.70	1.64	1.80	1.61	1.85	1.69	1.66	1.48	1.64




Velocity vs. Depth Scattergraph
SSMH3N1WSW020046
Feet per Second
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW020046
Million Gallons per Day
2.0
1.8
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
0
2
4
6
8
10
12
14
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.07	0.07	0.11	0.11	0.08	0.07	0.09	0.09	0.07	0.09	0.11	0.08	0.08	0.08
1:00	0.06	0.06	0.07	0.07	0.08	0.06	0.07	0.06	0.05	0.06	0.07	0.07	0.07	0.07
2:00	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.06	0.06	0.06	0.06	0.06	0.07
3:00	0.06	0.05	0.07	0.06	0.07	0.07	0.07	0.06	0.07	0.06	0.07	0.07	0.07	0.07
4:00	0.06	0.06	0.06	0.06	0.07	0.06	0.07	0.06	0.06	0.06	0.06	0.07	0.06	0.07
5:00	0.07	0.06	0.06	0.06	0.07	0.06	0.07	0.06	0.05	0.05	0.06	0.07	0.07	0.06
6:00	0.08	0.08	0.07	0.07	0.09	0.09	0.10	0.08	0.07	0.07	0.07	0.08	0.09	0.09
7:00	0.09	0.09	0.08	0.09	0.10	0.11	0.11	0.08	0.08	0.08	0.09	0.10	0.11	0.11
8:00	0.11	0.11	0.12	0.12	0.13	0.14	0.13	0.12	0.11	0.13	0.11	0.14	0.14	0.12
9:00	0.12	0.16	0.19	0.14	0.15	0.15	0.16	0.14	0.15	0.18	0.14	0.14	0.14	0.15
10:00	0.13	0.18	0.18	0.18	0.17	0.17	0.16	0.15	0.18	0.22	0.17	0.16	0.17	0.16
11:00	0.16	0.21	0.24	0.21	0.20	0.18	0.17	0.17	0.19	0.26	0.21	0.18	0.18	0.19
12:00	0.19	0.24	0.26	0.24	0.19	0.20	0.19	0.20	0.20	0.25	0.22	0.18	0.18	0.23
13:00	0.20	0.23	0.25	0.23	0.19	0.21	0.22	0.19	0.21	0.26	0.21	0.20	0.17	0.21
14:00	0.19	0.22	0.26	0.23	0.20	0.19	0.19	0.22	0.21	0.25	0.22	0.22	0.19	0.24
15:00	0.17	0.21	0.24	0.24	0.20	0.20	0.18	0.18	0.20	0.23	0.22	0.20	0.18	0.21
16:00	0.17	0.20	0.22	0.22	0.18	0.16	0.18	0.17	0.20	0.23	0.20	0.18	0.16	0.22
17:00	0.17	0.19	0.22	0.21	0.17	0.17	0.18	0.15	0.18	0.18	0.20	0.19	0.17	0.22
18:00	0.17	0.18	0.19	0.19	0.17	0.18	0.18	0.16	0.18	0.21	0.18	0.17	0.17	0.24
19:00	0.15	0.17	0.17	0.17	0.16	0.16	0.17	0.16	0.16	0.17	0.16	0.18	0.17	0.22
20:00	0.15	0.17	0.17	0.17	0.16	0.16	0.17	0.14	0.15	0.16	0.17	0.16	0.16	0.21
21:00	0.15	0.16	0.15	0.17	0.17	0.15	0.17	0.15	0.15	0.16	0.16	0.15	0.17	0.19
22:00	0.13	0.15	0.14	0.15	0.15	0.14	0.15	0.15	0.15	0.16	0.15	0.15	0.16	0.16
23:00	0.10	0.14	0.13	0.12	0.11	0.10	0.11	0.12	0.14	0.13	0.11	0.11	0.12	0.17
Average	0.12	0.14	0.15	0.15	0.14	0.13	0.14	0.13	0.14	0.15	0.14	0.14	0.13	0.16
Median	0.13	0.16	0.16	0.16	0.15	0.15	0.16	0.14	0.15	0.16	0.15	0.15	0.16	0.17
Max Hr. Mean	0.20	0.24	0.26	0.24	0.20	0.21	0.22	0.22	0.21	0.26	0.22	0.22	0.19	0.24
Min Hr. Mean	0.06	0.05	0.06	0.06	0.07	0.06	0.06	0.05	0.05	0.05	0.06	0.06	0.06	0.06
Inst. Max	0.21	0.25	0.27	0.26	0.22	0.23	0.23	0.23	0.22	0.29	0.24	0.23	0.20	0.26
Inst. Min	0.05	0.05	0.05	0.06	0.06	0.05	0.06	0.05	0.05	0.05	0.05	0.05	0.05	0.06

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.42	1.37	1.66	1.60	1.46	1.40	1.50	1.48	1.37	1.44	1.64	1.42	1.46	1.42
1:00	1.40	1.37	1.37	1.45	1.50	1.34	1.37	1.31	1.27	1.31	1.43	1.38	1.43	1.37
2:00	1.39	1.30	1.33	1.37	1.40	1.35	1.36	1.30	1.29	1.32	1.37	1.35	1.38	1.35
3:00	1.41	1.28	1.35	1.34	1.38	1.39	1.37	1.34	1.34	1.33	1.42	1.36	1.38	1.34
4:00	1.44	1.34	1.35	1.36	1.35	1.36	1.37	1.28	1.35	1.34	1.37	1.35	1.33	1.31
5:00	1.48	1.45	1.35	1.37	1.44	1.36	1.38	1.29	1.32	1.29	1.36	1.34	1.39	1.30
6:00	1.51	1.50	1.42	1.41	1.52	1.55	1.47	1.50	1.39	1.36	1.40	1.47	1.52	1.45
7:00	1.59	1.60	1.49	1.60	1.57	1.67	1.56	1.50	1.45	1.47	1.52	1.54	1.68	1.62
8:00	1.73	1.70	1.70	1.68	1.67	1.77	1.66	1.65	1.55	1.70	1.65	1.72	1.76	1.65
9:00	1.77	1.86	1.94	1.77	1.73	1.79	1.79	1.73	1.76	1.88	1.79	1.76	1.79	1.67
10:00	1.78	1.92	1.93	1.83	1.84	1.83	1.74	1.72	1.92	2.02	1.91	1.83	1.86	1.74
11:00	1.91	2.07	2.16	1.99	2.01	1.89	1.86	1.78	1.94	2.14	2.03	1.90	1.92	1.80
12:00	1.97	2.13	2.23	2.12	1.94	2.01	1.93	1.98	1.97	2.11	2.07	1.90	1.87	1.95
13:00	2.00	2.04	2.17	2.11	1.92	2.07	1.93	1.93	2.01	2.14	1.99	1.93	1.87	1.89
14:00	1.94	2.09	2.16	2.05	2.03	1.98	1.90	1.98	1.99	2.08	2.01	1.95	1.93	1.92
15:00	1.87	2.03	2.08	2.10	1.96	1.97	1.93	1.96	1.96	2.07	2.00	1.94	1.93	1.87
16:00	1.90	2.11	2.05	2.11	1.90	1.87	1.89	1.90	1.95	2.10	1.96	1.91	1.87	1.91
17:00	1.90	2.00	2.05	2.06	1.90	1.87	1.86	1.80	1.89	1.89	1.95	1.89	1.86	1.88
18:00	1.87	1.94	1.91	1.97	1.82	1.94	1.88	1.84	1.88	1.98	1.96	1.86	1.90	1.95
19:00	1.77	1.94	1.81	1.88	1.80	1.88	1.82	1.78	1.83	1.88	1.85	1.92	1.89	1.91
20:00	1.84	1.94	1.87	1.90	1.83	1.89	1.84	1.76	1.79	1.81	1.87	1.85	1.85	1.90
21:00	1.87	1.89	1.79	1.82	1.89	1.87	1.84	1.77	1.80	1.85	1.79	1.85	1.82	1.88
22:00	1.75	1.81	1.76	1.72	1.82	1.75	1.75	1.70	1.77	1.80	1.80	1.83	1.75	1.78
23:00	1.58	1.80	1.72	1.65	1.64	1.56	1.64	1.51	1.70	1.74	1.67	1.57	1.67	1.79
Average	1.71	1.77	1.78	1.76	1.72	1.72	1.69	1.66	1.69	1.75	1.74	1.70	1.71	1.69
Median	1.78	1.87	1.81	1.77	1.77	1.83	1.77	1.72	1.77	1.84	1.80	1.81	1.81	1.79
Max Hr. Mean	2.00	2.13	2.23	2.12	2.03	2.07	1.93	1.98	2.01	2.14	2.07	1.95	1.93	1.95
Min Hr. Mean	1.39	1.28	1.33	1.34	1.35	1.34	1.36	1.28	1.27	1.29	1.36	1.34	1.33	1.30
Inst. Max	2.05	2.19	2.30	2.19	2.10	2.16	2.00	2.05	2.08	2.21	2.13	2.00	2.00	2.01
Inst. Min	1.32	1.25	1.29	1.30	1.29	1.26	1.29	1.24	1.23	1.26	1.33	1.29	1.26	1.25

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW020046

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.77	1.79	2.23	2.36	1.98	1.84	2.06	2.05	1.94	2.19	2.24	1.95	1.91	2.02
1:00	1.67	1.65	1.83	1.83	1.87	1.66	1.86	1.71	1.62	1.73	1.90	1.80	1.78	1.79
2:00	1.61	1.59	1.79	1.71	1.78	1.68	1.79	1.61	1.69	1.70	1.78	1.66	1.65	1.82
3:00	1.70	1.55	1.89	1.75	1.78	1.84	1.88	1.79	1.87	1.77	1.91	1.85	1.91	1.89
4:00	1.70	1.62	1.77	1.80	1.82	1.63	1.88	1.69	1.79	1.69	1.78	1.84	1.77	1.88
5:00	1.73	1.66	1.67	1.68	1.88	1.70	1.96	1.67	1.60	1.58	1.61	1.81	1.81	1.83
6:00	1.86	1.91	1.80	1.79	2.03	2.02	2.31	1.98	1.92	1.82	1.84	2.01	2.02	2.15
7:00	1.98	1.96	1.94	2.03	2.17	2.17	2.42	1.97	2.06	2.04	2.04	2.15	2.22	2.35
8:00	2.24	2.16	2.37	2.34	2.45	2.55	2.59	2.33	2.28	2.51	2.32	2.57	2.51	2.44
9:00	2.30	2.66	2.94	2.56	2.70	2.65	2.74	2.58	2.70	2.93	2.60	2.63	2.57	2.73
10:00	2.36	2.86	2.88	2.93	2.81	2.83	2.81	2.67	2.91	3.17	2.80	2.69	2.85	2.84
11:00	2.68	2.99	3.23	3.11	2.95	2.87	2.85	2.86	3.02	3.48	3.14	2.94	2.87	3.07
12:00	2.91	3.31	3.33	3.33	2.94	3.00	3.04	3.04	3.03	3.42	3.20	2.92	2.92	3.39
13:00	3.01	3.29	3.35	3.21	3.02	3.07	3.30	2.93	3.06	3.43	3.13	3.09	2.78	3.29
14:00	2.92	3.17	3.43	3.25	2.99	2.95	3.04	3.27	3.09	3.41	3.18	3.25	3.04	3.54
15:00	2.80	3.06	3.32	3.27	3.03	3.03	2.87	2.87	3.00	3.27	3.22	3.04	2.91	3.32
16:00	2.78	2.88	3.12	3.11	2.87	2.73	2.89	2.77	3.08	3.19	3.03	2.89	2.66	3.29
17:00	2.78	2.88	3.13	3.10	2.81	2.77	2.94	2.67	2.97	2.96	3.09	2.99	2.79	3.40
18:00	2.81	2.83	2.98	2.94	2.86	2.82	2.95	2.79	2.93	3.18	2.87	2.89	2.84	3.50
19:00	2.62	2.78	2.87	2.84	2.76	2.63	2.82	2.77	2.78	2.83	2.78	2.83	2.75	3.30
20:00	2.61	2.75	2.79	2.83	2.80	2.65	2.79	2.61	2.63	2.72	2.79	2.74	2.68	3.21
21:00	2.61	2.70	2.71	2.87	2.84	2.62	2.80	2.72	2.69	2.77	2.73	2.62	2.83	3.02
22:00	2.43	2.65	2.52	2.72	2.63	2.56	2.72	2.72	2.66	2.73	2.59	2.67	2.82	2.80
23:00	2.25	2.54	2.48	2.34	2.23	2.19	2.31	2.49	2.60	2.46	2.30	2.34	2.43	2.86
Average	2.34	2.47	2.60	2.57	2.50	2.44	2.57	2.44	2.50	2.62	2.54	2.51	2.47	2.74
Median	2.42	2.71	2.74	2.78	2.72	2.63	2.77	2.62	2.68	2.75	2.68	2.69	2.70	2.88
Max Hr. Mean	3.01	3.31	3.43	3.33	3.03	3.07	3.30	3.27	3.09	3.48	3.22	3.25	3.04	3.54
Min Hr. Mean	1.61	1.55	1.67	1.68	1.78	1.63	1.79	1.61	1.60	1.58	1.61	1.66	1.65	1.79
Inst. Max	3.06	3.39	3.50	3.47	3.13	3.19	3.44	3.33	3.15	3.63	3.40	3.31	3.08	3.69
Inst. Min	1.55	1.51	1.62	1.64	1.69	1.52	1.70	1.47	1.47	1.52	1.57	1.52	1.48	1.69

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 06
Address: Litchfield N off Bell Road
MH ID# SSMH4N1WSW330113

Date: 06/09/08
GPS: 33.374960N -112.203199W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 204L00480
Sensor Serial # 205J00125
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris Yes - paper
Grease No
Pests Yes - roaches

Down Manhole

Hydraulics:
Low to moderate flow conditions

Comments:
Debris in bench area at time of installation

Photos
MH #SSMH4N1WSW330113
Site #06

Site ID

Down Manhole

24” Influent

24” Effluent

18” Lateral

Manhole Cover Top

Photos
MH #SSMH4N1WSW330113
Site #06

Manhole Cover Bottom

Location Summary

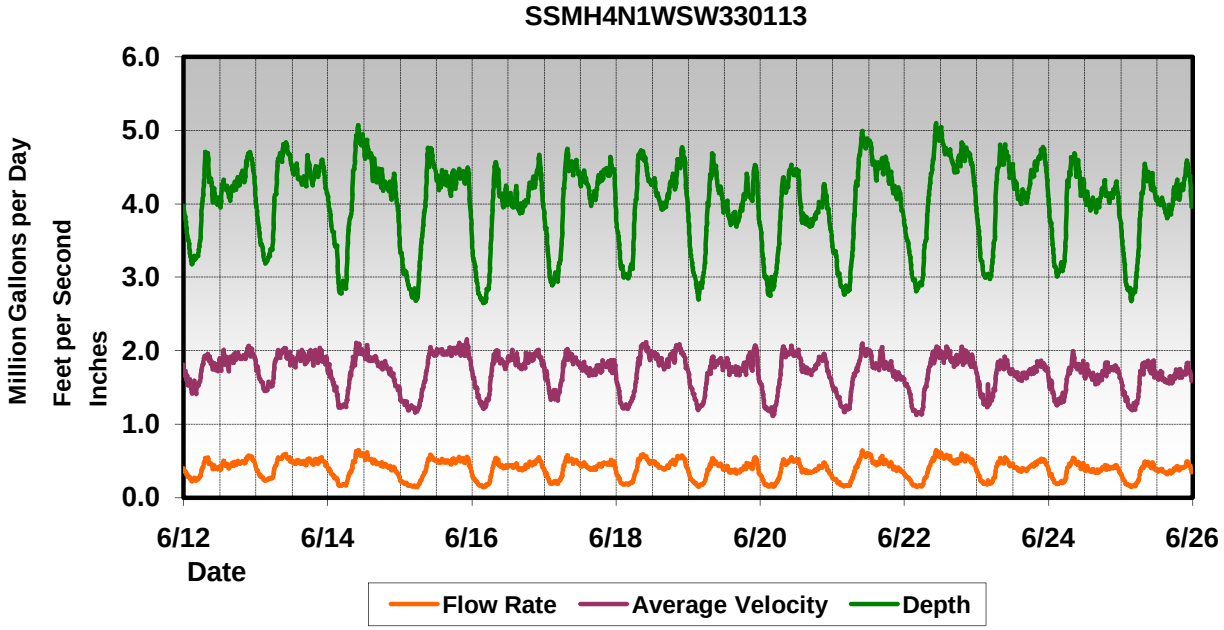
Site	**SSMH4N1WSW330113**	
Address	**Litchfield N of Bell Road**	
Diameter	**24**	Inches
GPS	**33.374960N -112.203199W**	

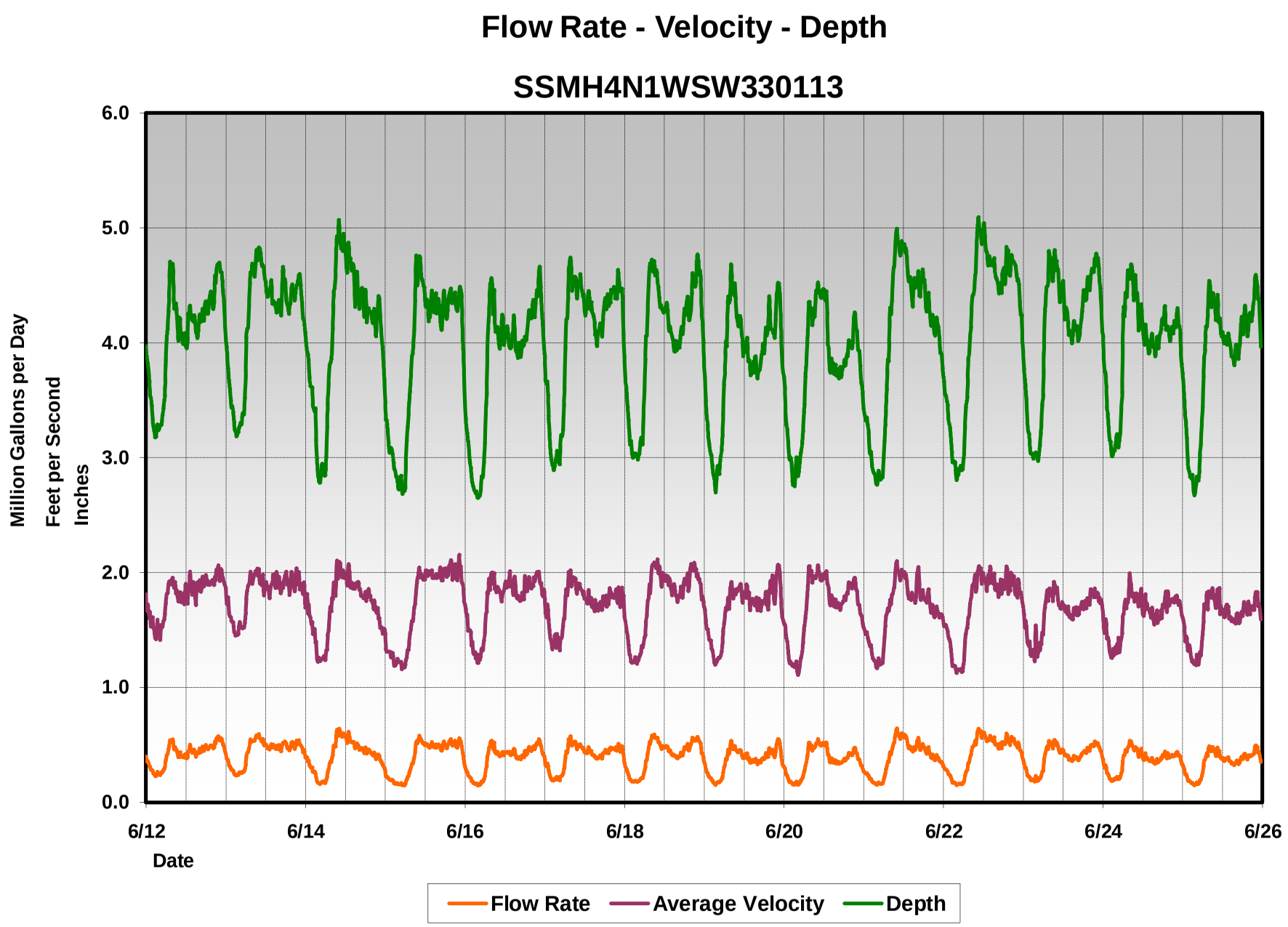
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.00
Maximum	5.10
Minimum	2.65
Max d/D	21.2%

Flow velocity	
	Feet per Second
Average	1.71
Maximum	2.15
Minimum	1.11

Flow Rate	
	Million Gallons per Day
Average	0.39
Maximum	0.64
Minimum	0.15
Peak Factor	1.64



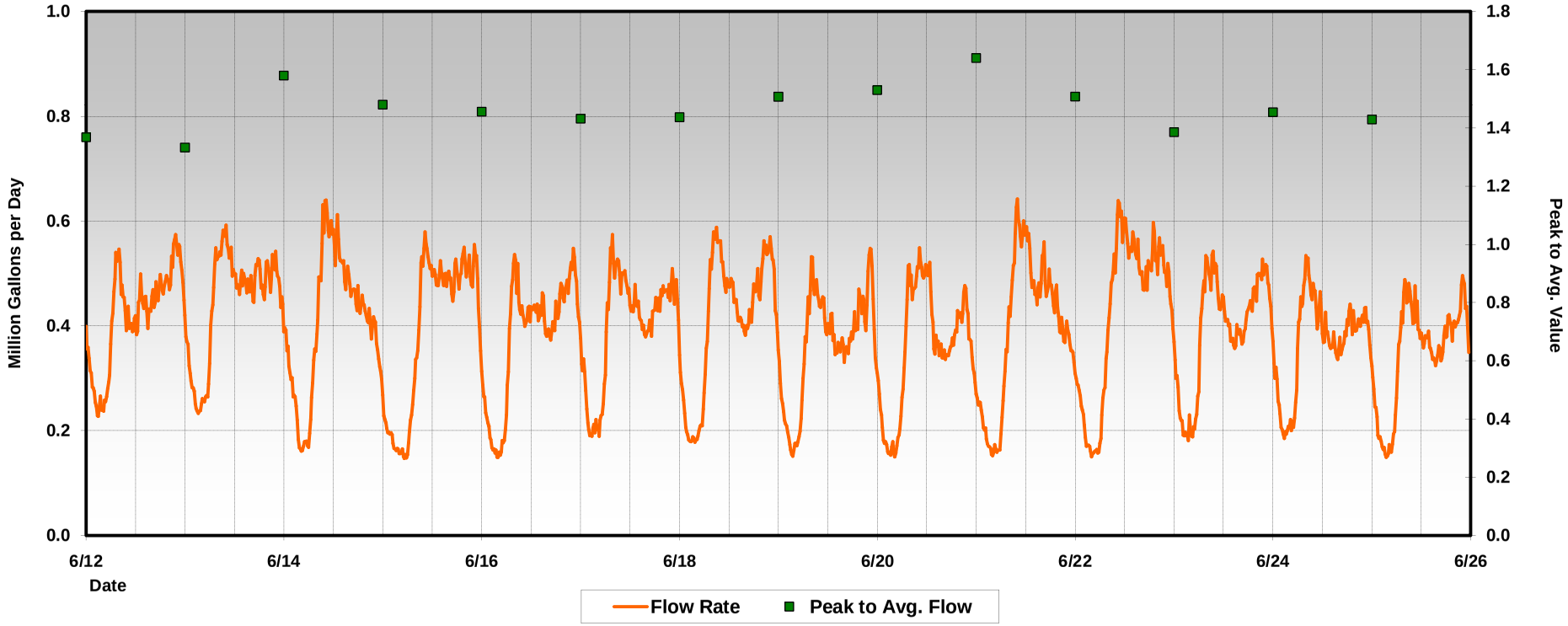

Flow Rate - Velocity - Depth
SSMH4N1WSW330113
Million Gallons per Day
Feet per Second
Inches
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

Peak to Average Flow Rate

Site ID SSMH4N1WSW330113

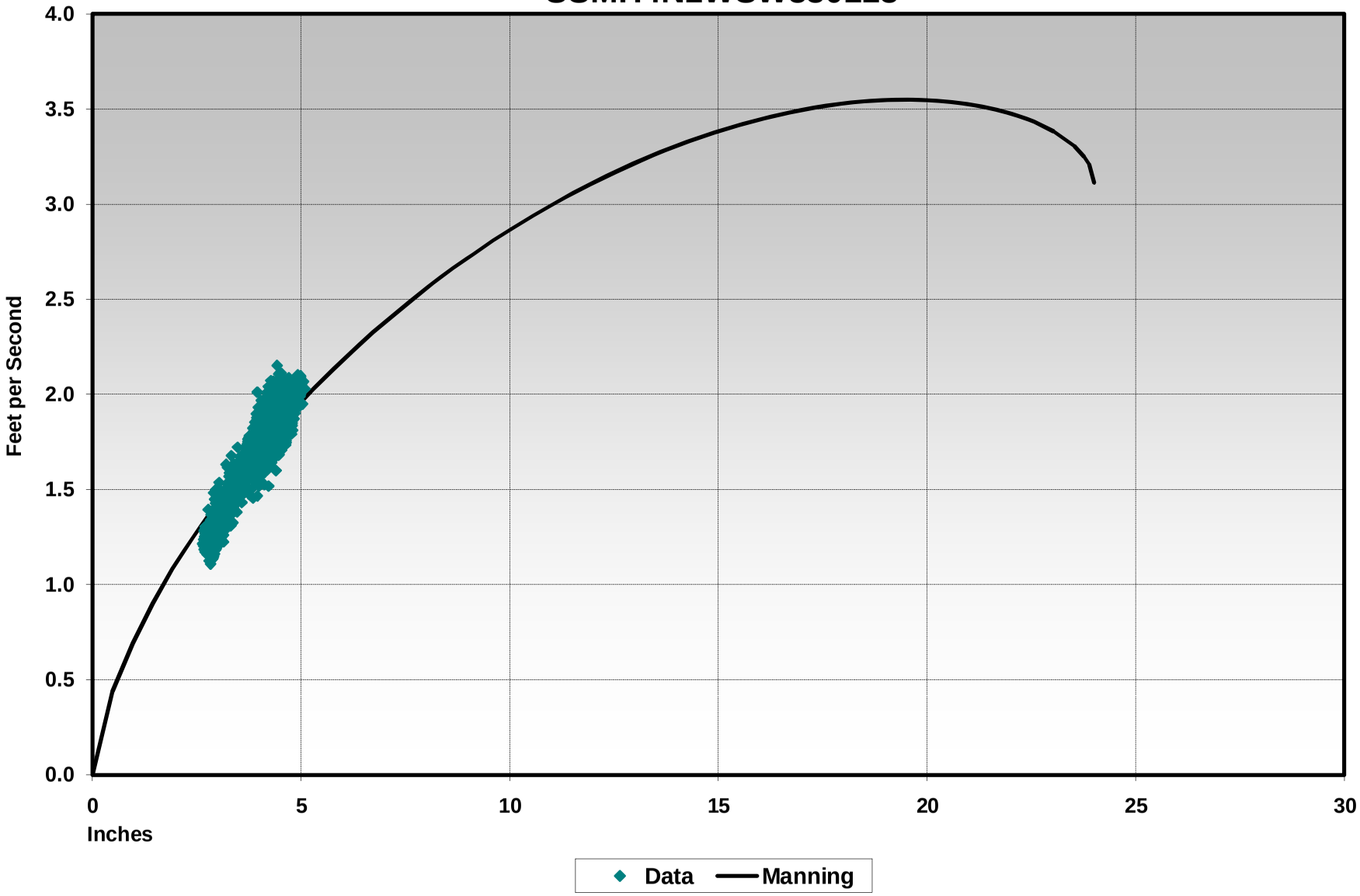
Start Date 6/12/2008
End Date 6/25/2008

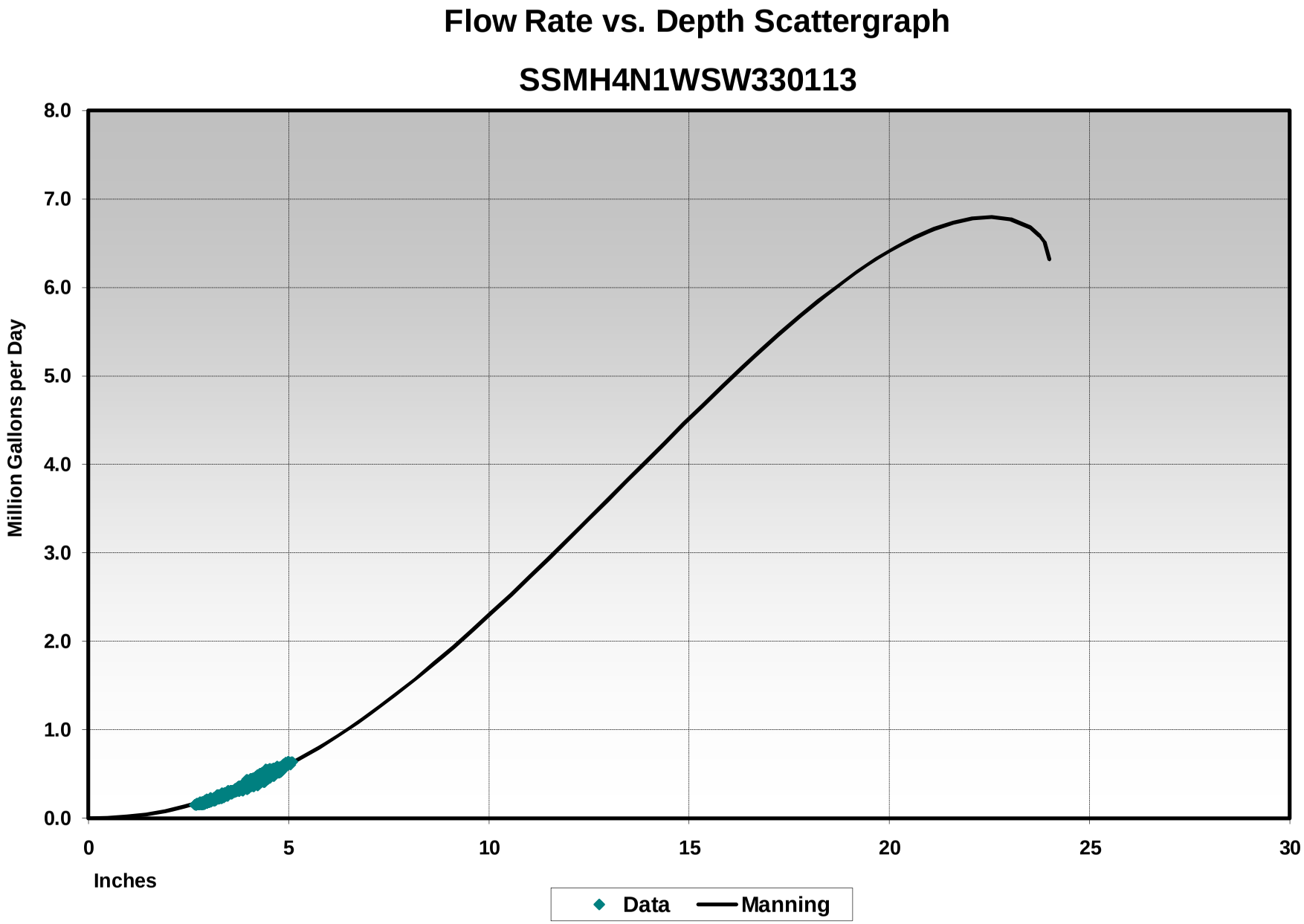
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.37	1.33	1.58	1.48	1.46	1.43	1.44	1.51	1.53	1.64	1.51	1.39	1.45	1.44



Velocity vs. Depth Scattergraph

SSMH4N1WSW330113




Flow Rate vs. Depth Scattergraph
SSMH4N1WSW330113
Million Gallons per Day
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.36	0.38	0.38	0.23	0.28	0.34	0.31	0.31	0.28	0.26	0.30	0.33	0.33	0.29
1:00	0.30	0.30	0.32	0.20	0.22	0.26	0.22	0.23	0.20	0.23	0.26	0.24	0.26	0.21
2:00	0.25	0.26	0.27	0.18	0.17	0.19	0.18	0.19	0.17	0.19	0.20	0.20	0.20	0.18
3:00	0.24	0.24	0.20	0.16	0.16	0.21	0.18	0.16	0.17	0.16	0.17	0.20	0.20	0.16
4:00	0.25	0.26	0.16	0.16	0.16	0.20	0.19	0.18	0.16	0.16	0.16	0.20	0.21	0.16
5:00	0.29	0.27	0.18	0.15	0.19	0.25	0.22	0.22	0.20	0.16	0.16	0.23	0.24	0.20
6:00	0.42	0.40	0.21	0.19	0.31	0.39	0.33	0.34	0.30	0.24	0.21	0.37	0.41	0.33
7:00	0.52	0.52	0.33	0.26	0.48	0.54	0.48	0.44	0.47	0.36	0.31	0.49	0.46	0.42
8:00	0.50	0.54	0.45	0.36	0.51	0.51	0.56	0.50	0.47	0.45	0.43	0.51	0.52	0.46
9:00	0.43	0.57	0.56	0.50	0.43	0.50	0.57	0.47	0.49	0.56	0.51	0.51	0.47	0.46
10:00	0.41	0.56	0.62	0.56	0.41	0.50	0.53	0.44	0.52	0.60	0.61	0.49	0.44	0.42
11:00	0.40	0.52	0.58	0.52	0.42	0.47	0.48	0.41	0.50	0.57	0.60	0.44	0.44	0.40
12:00	0.41	0.49	0.55	0.50	0.44	0.43	0.48	0.40	0.51	0.58	0.59	0.43	0.39	0.37
13:00	0.46	0.48	0.56	0.48	0.43	0.45	0.46	0.38	0.41	0.50	0.54	0.40	0.38	0.38
14:00	0.44	0.49	0.51	0.50	0.43	0.42	0.42	0.36	0.37	0.46	0.56	0.37	0.37	0.35
15:00	0.42	0.47	0.50	0.49	0.41	0.39	0.40	0.36	0.35	0.47	0.53	0.38	0.35	0.33
16:00	0.45	0.47	0.47	0.49	0.38	0.39	0.40	0.35	0.34	0.53	0.48	0.38	0.36	0.35
17:00	0.47	0.51	0.45	0.49	0.40	0.41	0.43	0.37	0.35	0.48	0.50	0.41	0.37	0.37
18:00	0.48	0.50	0.44	0.49	0.43	0.44	0.47	0.40	0.37	0.46	0.52	0.44	0.42	0.40
19:00	0.49	0.48	0.44	0.53	0.47	0.45	0.48	0.43	0.41	0.45	0.56	0.46	0.41	0.40
20:00	0.49	0.50	0.42	0.51	0.47	0.47	0.53	0.44	0.42	0.40	0.54	0.49	0.40	0.40
21:00	0.55	0.51	0.40	0.50	0.50	0.46	0.54	0.44	0.46	0.38	0.53	0.50	0.41	0.43
22:00	0.55	0.51	0.38	0.53	0.52	0.48	0.54	0.54	0.39	0.39	0.50	0.51	0.42	0.47
23:00	0.49	0.45	0.32	0.42	0.44	0.45	0.44	0.38	0.31	0.35	0.43	0.44	0.38	0.30
Average	0.42	0.44	0.41	0.39	0.38	0.40	0.41	0.36	0.36	0.39	0.42	0.39	0.37	0.34
Median	0.44	0.48	0.42	0.48	0.42	0.43	0.45	0.38	0.36	0.42	0.50	0.41	0.39	0.38
Max Hr. Mean	0.55	0.57	0.62	0.56	0.52	0.54	0.57	0.54	0.52	0.60	0.61	0.51	0.52	0.47
Min Hr. Mean	0.24	0.24	0.16	0.15	0.16	0.19	0.18	0.16	0.16	0.16	0.16	0.20	0.20	0.16
Inst. Max	0.57	0.59	0.64	0.58	0.55	0.57	0.59	0.55	0.55	0.64	0.64	0.54	0.53	0.50
Inst. Min	0.23	0.23	0.16	0.15	0.15	0.19	0.18	0.15	0.15	0.15	0.15	0.18	0.19	0.15

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.72	1.77	1.73	1.36	1.66	1.69	1.55	1.62	1.51	1.49	1.54	1.61	1.56	1.53
1:00	1.59	1.61	1.63	1.30	1.49	1.54	1.34	1.45	1.29	1.42	1.47	1.42	1.45	1.38
2:00	1.52	1.52	1.51	1.25	1.34	1.36	1.22	1.33	1.20	1.32	1.29	1.32	1.28	1.30
3:00	1.49	1.46	1.32	1.22	1.27	1.43	1.24	1.21	1.20	1.22	1.18	1.34	1.32	1.21
4:00	1.48	1.54	1.24	1.22	1.25	1.39	1.26	1.25	1.14	1.21	1.15	1.33	1.35	1.23
5:00	1.58	1.53	1.26	1.18	1.35	1.50	1.35	1.37	1.30	1.21	1.15	1.39	1.39	1.31
6:00	1.82	1.78	1.34	1.26	1.65	1.76	1.52	1.63	1.58	1.48	1.33	1.63	1.68	1.61
7:00	1.92	1.95	1.62	1.42	1.89	1.96	1.81	1.75	1.95	1.68	1.57	1.81	1.74	1.76
8:00	1.91	1.95	1.84	1.61	1.97	1.92	2.03	1.86	1.96	1.78	1.80	1.83	1.90	1.81
9:00	1.81	2.01	1.95	1.85	1.86	1.89	2.06	1.84	1.96	1.94	1.91	1.85	1.78	1.79
10:00	1.77	1.93	2.06	1.99	1.83	1.88	2.04	1.86	2.01	2.03	1.99	1.79	1.77	1.74
11:00	1.78	1.90	1.98	1.96	1.80	1.83	1.94	1.81	1.95	1.97	1.98	1.71	1.79	1.72
12:00	1.80	1.88	1.96	1.98	1.89	1.76	1.94	1.83	1.98	1.98	1.95	1.69	1.69	1.64
13:00	1.90	1.84	1.96	1.99	1.93	1.78	1.93	1.79	1.85	1.83	1.91	1.66	1.70	1.70
14:00	1.85	1.94	1.88	1.98	1.89	1.72	1.84	1.74	1.76	1.79	1.99	1.61	1.65	1.60
15:00	1.84	1.92	1.90	1.97	1.85	1.71	1.83	1.75	1.73	1.78	1.90	1.65	1.59	1.58
16:00	1.88	1.89	1.85	1.99	1.77	1.69	1.78	1.74	1.71	1.99	1.84	1.65	1.62	1.61
17:00	1.91	1.92	1.79	1.98	1.80	1.73	1.83	1.72	1.72	1.79	1.87	1.71	1.62	1.60
18:00	1.93	1.95	1.79	2.01	1.88	1.75	1.92	1.76	1.78	1.77	1.90	1.72	1.73	1.68
19:00	1.90	1.90	1.80	2.05	1.93	1.79	1.93	1.78	1.86	1.79	1.97	1.75	1.77	1.69
20:00	1.92	1.92	1.73	2.00	1.90	1.80	2.05	1.92	1.89	1.69	1.93	1.80	1.74	1.69
21:00	2.01	1.95	1.67	1.98	1.97	1.80	2.03	1.83	1.92	1.64	1.88	1.81	1.76	1.71
22:00	1.99	1.91	1.56	2.07	1.95	1.78	1.95	2.04	1.75	1.65	1.87	1.79	1.76	1.80
23:00	1.93	1.87	1.50	1.86	1.84	1.82	1.80	1.70	1.61	1.63	1.79	1.75	1.70	1.25
Average	1.80	1.83	1.70	1.73	1.75	1.72	1.76	1.69	1.69	1.67	1.71	1.65	1.64	1.58
Median	1.85	1.89	1.76	1.94	1.83	1.77	1.88	1.75	1.75	1.72	1.84	1.70	1.68	1.65
Max Hr. Mean	2.01	2.01	2.06	2.07	1.97	1.96	2.06	2.04	2.01	2.03	1.99	1.85	1.90	1.81
Min Hr. Mean	1.48	1.46	1.24	1.18	1.25	1.36	1.22	1.21	1.14	1.21	1.15	1.32	1.28	1.21
Inst. Max	2.06	2.04	2.10	2.15	2.01	2.02	2.11	2.07	2.07	2.10	2.06	1.92	1.99	1.87
Inst. Min	1.42	1.45	1.22	1.16	1.22	1.32	1.21	1.20	1.11	1.17	1.13	1.23	1.26	1.19

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW330113

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.86	3.92	3.98	3.35	3.32	3.72	3.68	3.59	3.51	3.37	3.61	3.75	3.86	3.56
1:00	3.55	3.55	3.70	3.08	3.02	3.30	3.27	3.17	3.10	3.22	3.40	3.32	3.43	3.09
2:00	3.26	3.35	3.47	2.99	2.77	2.93	3.05	2.96	2.89	2.98	3.11	3.06	3.10	2.84
3:00	3.24	3.21	3.11	2.84	2.69	2.99	3.02	2.77	2.86	2.84	2.95	3.01	3.07	2.74
4:00	3.28	3.28	2.81	2.76	2.68	3.00	3.04	2.91	2.89	2.82	2.85	3.02	3.14	2.80
5:00	3.46	3.41	2.91	2.72	2.87	3.27	3.21	3.16	3.11	2.82	2.91	3.27	3.34	3.08
6:00	4.07	4.00	3.15	3.03	3.50	3.99	3.89	3.84	3.60	3.21	3.18	4.04	4.24	3.74
7:00	4.59	4.51	3.78	3.53	4.35	4.61	4.53	4.33	4.21	3.87	3.69	4.57	4.51	4.22
8:00	4.48	4.62	4.24	3.97	4.44	4.53	4.66	4.56	4.23	4.37	4.22	4.67	4.61	4.41
9:00	4.21	4.75	4.79	4.57	4.14	4.52	4.64	4.39	4.32	4.78	4.52	4.66	4.49	4.38
10:00	4.14	4.78	4.94	4.70	4.01	4.53	4.43	4.19	4.47	4.89	4.99	4.63	4.32	4.25
11:00	4.03	4.63	4.86	4.52	4.15	4.44	4.29	4.04	4.42	4.82	4.94	4.43	4.25	4.14
12:00	4.05	4.45	4.73	4.36	4.09	4.29	4.31	3.97	4.42	4.82	4.94	4.35	4.08	4.05
13:00	4.25	4.48	4.74	4.24	3.99	4.38	4.17	3.88	3.99	4.61	4.74	4.20	4.01	4.03
14:00	4.21	4.35	4.61	4.36	4.10	4.28	4.04	3.77	3.81	4.44	4.69	4.06	3.99	3.96
15:00	4.08	4.29	4.47	4.36	3.97	4.07	3.95	3.82	3.76	4.52	4.65	4.13	3.95	3.85
16:00	4.21	4.31	4.37	4.27	3.92	4.12	3.99	3.74	3.73	4.53	4.50	4.08	3.98	3.94
17:00	4.28	4.55	4.37	4.30	3.98	4.16	4.12	3.91	3.76	4.52	4.51	4.17	4.11	4.07
18:00	4.29	4.38	4.31	4.27	4.06	4.35	4.29	4.02	3.83	4.47	4.61	4.41	4.25	4.19
19:00	4.41	4.35	4.27	4.43	4.25	4.36	4.29	4.25	3.95	4.35	4.75	4.49	4.12	4.15
20:00	4.40	4.44	4.23	4.38	4.31	4.46	4.46	4.11	3.98	4.20	4.68	4.57	4.08	4.22
21:00	4.63	4.49	4.19	4.33	4.36	4.42	4.56	4.18	4.21	4.12	4.69	4.66	4.13	4.38
22:00	4.65	4.53	4.29	4.43	4.54	4.55	4.68	4.49	3.97	4.14	4.55	4.72	4.21	4.50
23:00	4.39	4.23	3.87	4.02	4.18	4.34	4.24	3.97	3.66	3.87	4.22	4.36	3.99	3.13
Average	4.08	4.20	4.09	3.91	3.82	4.07	4.03	3.83	3.78	4.02	4.16	4.11	3.97	3.82
Median	4.20	4.36	4.25	4.25	4.03	4.30	4.16	3.91	3.82	4.25	4.52	4.29	4.08	4.04
Max Hr. Mean	4.65	4.78	4.94	4.70	4.54	4.61	4.68	4.56	4.47	4.89	4.99	4.72	4.61	4.50
Min Hr. Mean	3.24	3.21	2.81	2.72	2.68	2.93	3.02	2.77	2.86	2.82	2.85	3.01	3.07	2.74
Inst. Max	4.70	4.83	5.07	4.75	4.66	4.74	4.77	4.68	4.53	4.99	5.10	4.81	4.68	4.59
Inst. Min	3.18	3.19	2.78	2.68	2.65	2.89	2.99	2.70	2.75	2.77	2.81	2.97	3.01	2.67

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 07
Address: N Reems Road S of W Larkspur Drive
MH ID# SSMH3N1WSW170111

Date: 6/9/2008
GPS: 33.355312N -112.233708W

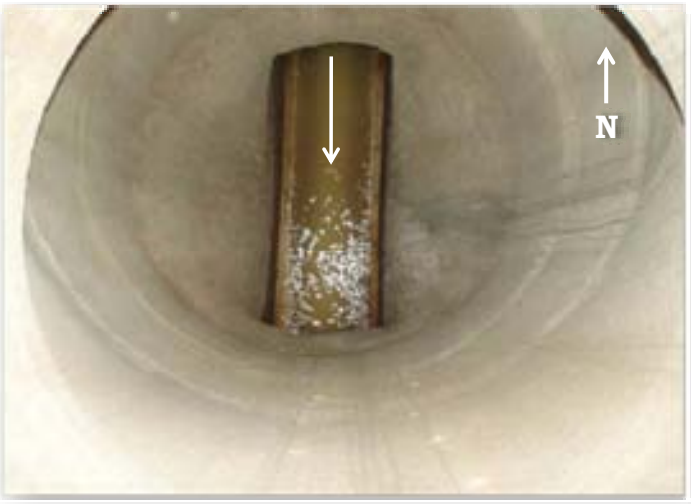
Overview

Street Level

Meter Details

Meter Type 215000
Serial # 20500083
Sensor Serial # Temp Tag 5
Telemetry None
Sample Rate 5 min

Down Manhole



Pipe Details and Manhole Condition

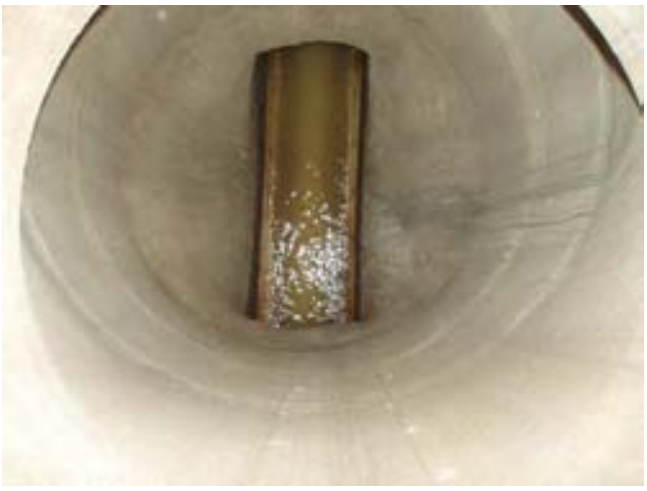
Pipe Size (in) Vert. 24" Horiz. 24"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Hydraulics:
Moderate to fast flow conditions at installation

Comments:
Good monitoring site

Photos
MH #SSMH3N1WSW170111
Site #07

Site ID



Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

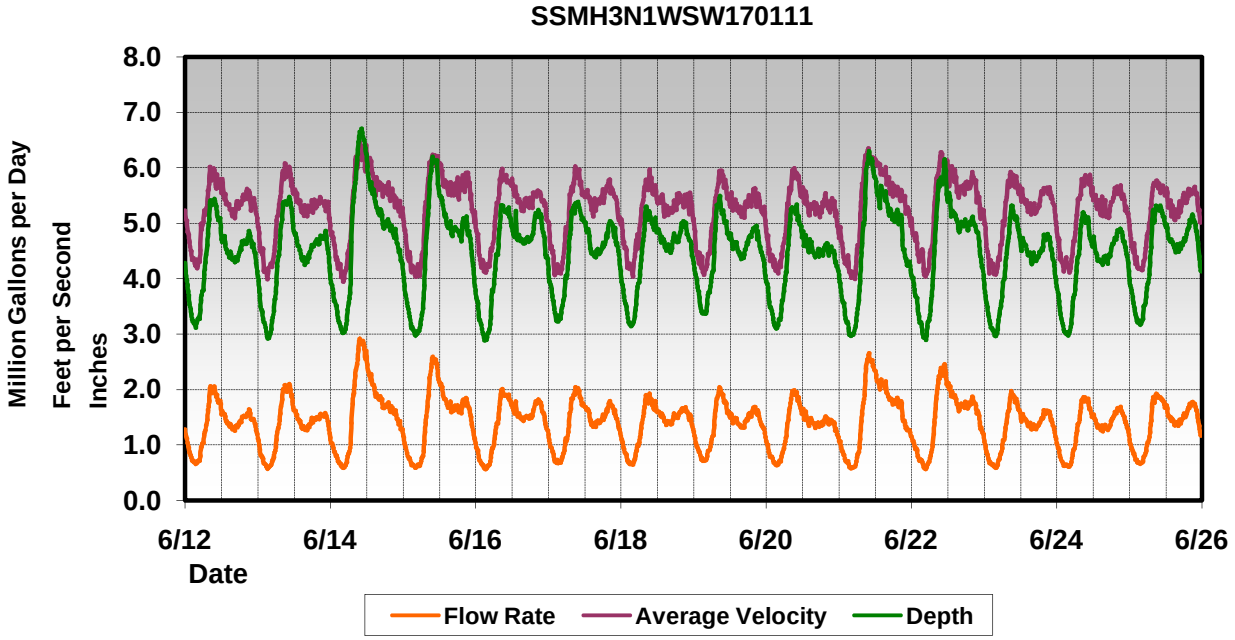
Site	**SSMH3N1WSW170111**
Address	**Reems Rd S of W Larkspur Drive**
Diameter	**24** Inches
GPS	**33.355312N -112.233708W**

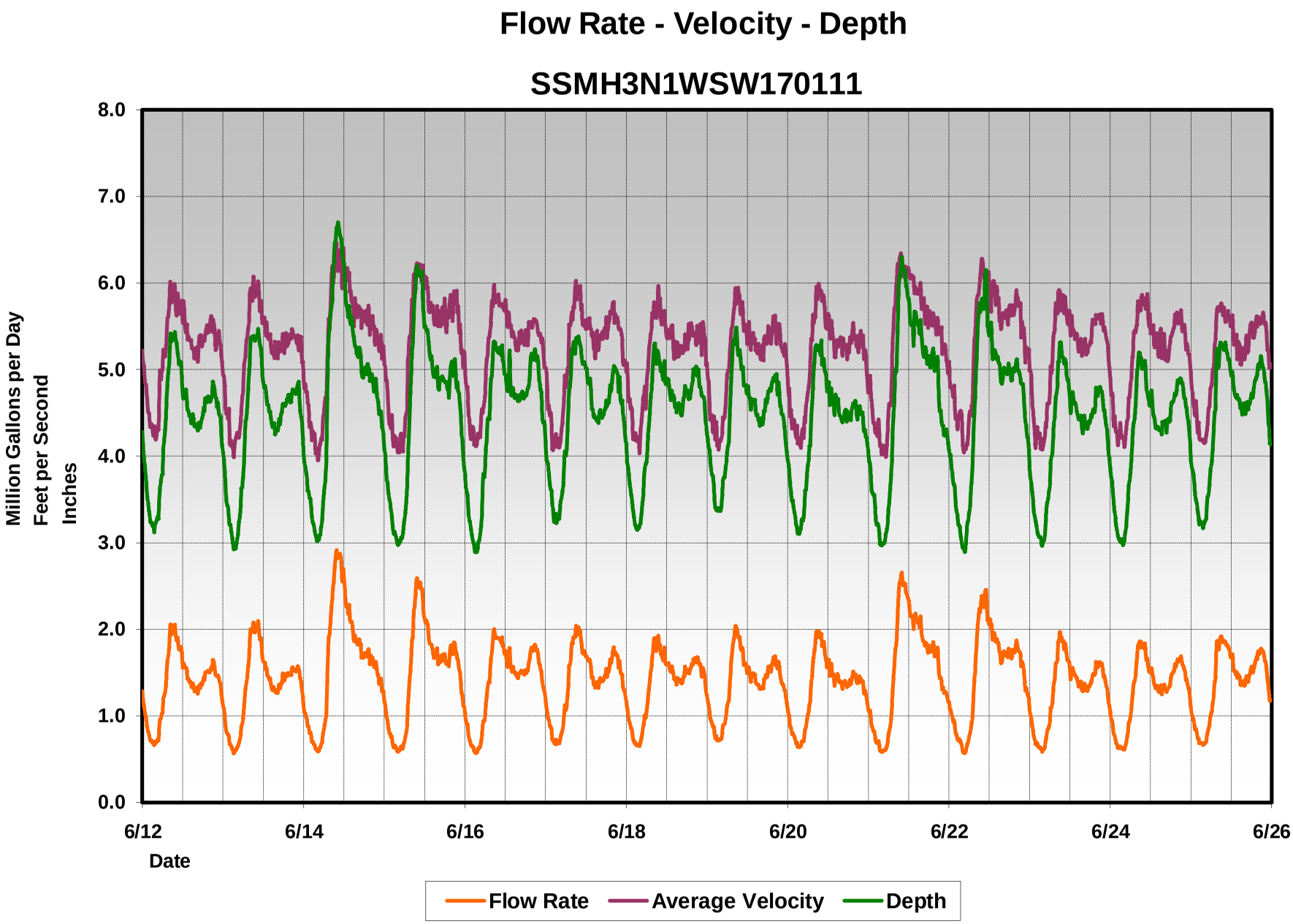
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.47
Maximum	6.70
Minimum	2.89
Max d/D	27.9%

Flow velocity	
	Feet per Second
Average	5.23
Maximum	6.46
Minimum	3.95

Flow Rate	
	Million Gallons per Day
Average	1.41
Maximum	2.91
Minimum	0.56
Peak Factor	2.07



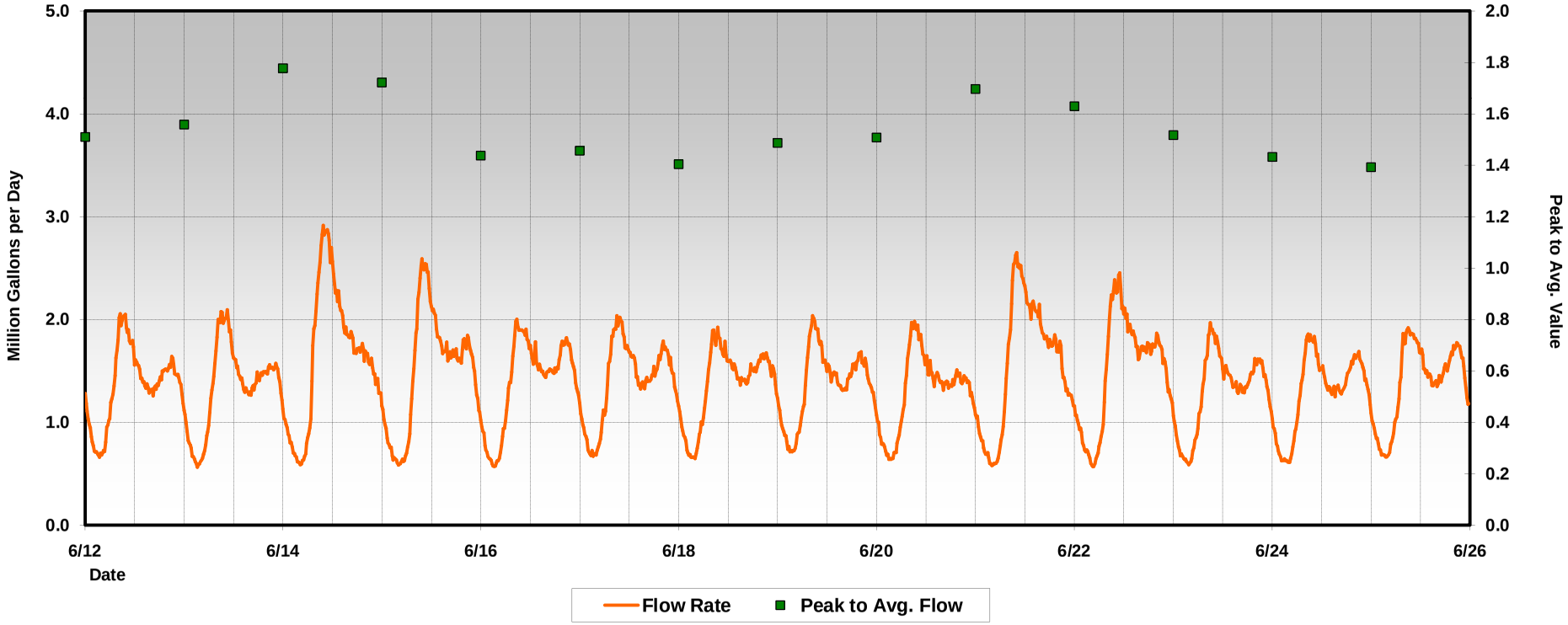

Flow Rate - Velocity - Depth
SSMH3N1WSW170111
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

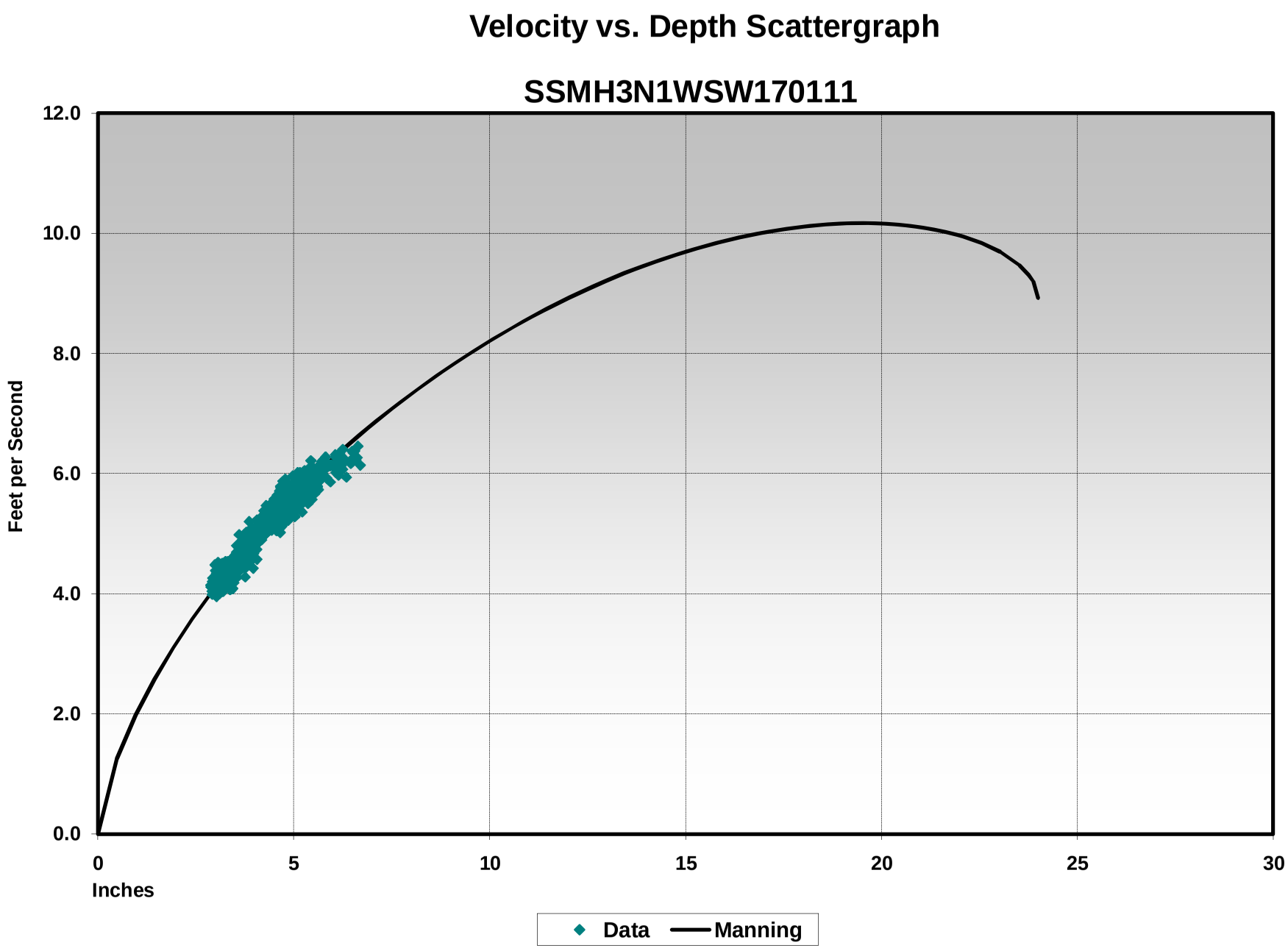
Peak to Average Flow Rate

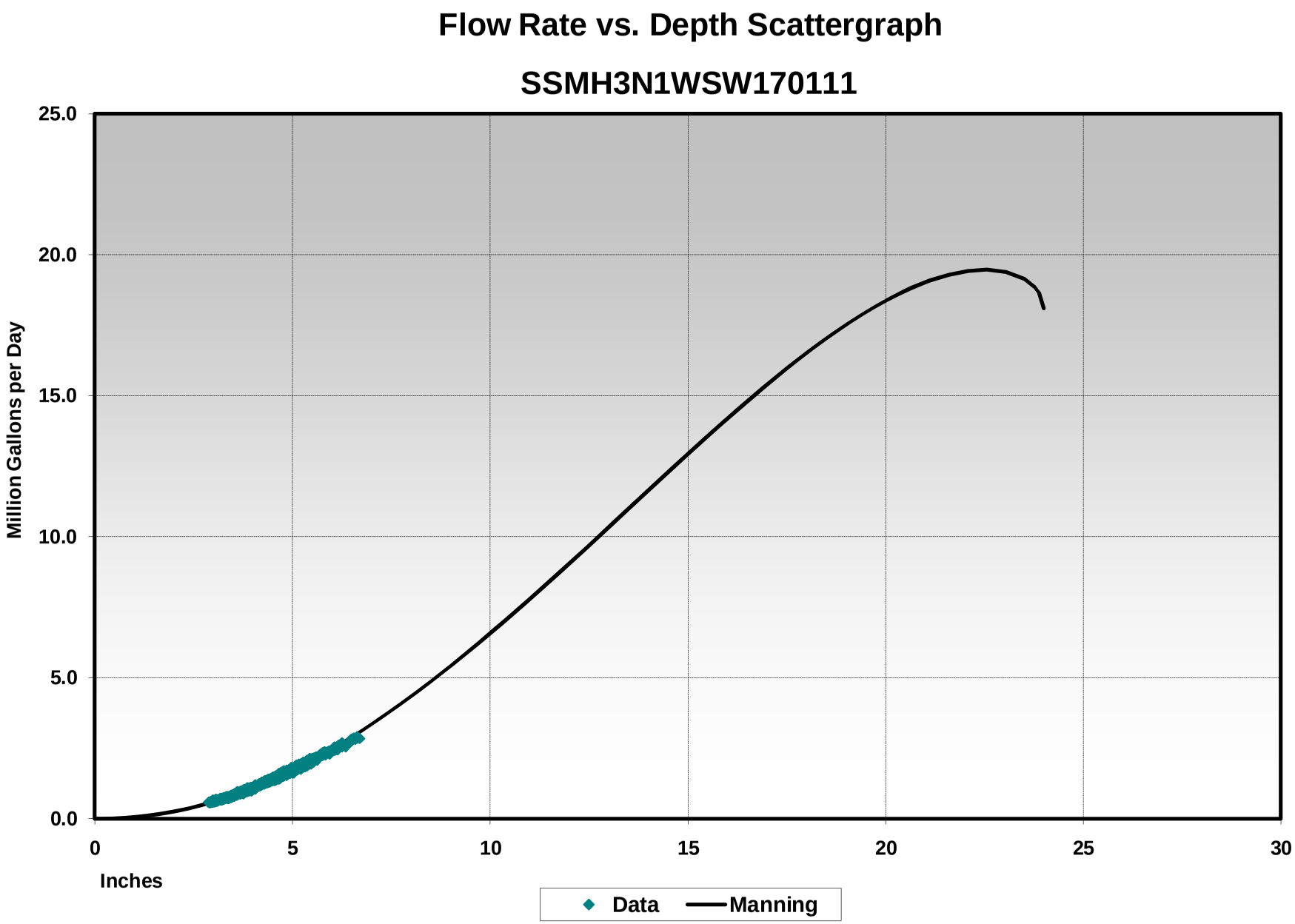
Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.51	1.56	1.78	1.72	1.44	1.46	1.40	1.49	1.51	1.70	1.63	1.52	1.43	1.39




Velocity vs. Depth Scattergraph
SSMH3N1WSW170111
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW170111
Million Gallons per Day
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.15	1.03	1.04	1.07	0.95	1.07	1.06	1.14	0.99	1.03	1.08	0.98	0.96	1.01
1:00	0.90	0.79	0.88	0.84	0.72	0.88	0.87	0.92	0.81	0.85	0.94	0.75	0.74	0.84
2:00	0.73	0.65	0.74	0.70	0.63	0.70	0.70	0.80	0.71	0.71	0.75	0.66	0.64	0.71
3:00	0.68	0.59	0.64	0.64	0.58	0.70	0.66	0.72	0.64	0.64	0.70	0.61	0.63	0.67
4:00	0.71	0.65	0.60	0.60	0.65	0.74	0.73	0.79	0.69	0.59	0.58	0.65	0.64	0.71
5:00	0.94	0.82	0.70	0.64	0.88	0.97	0.94	0.95	0.87	0.64	0.66	0.83	0.86	0.89
6:00	1.18	1.15	0.93	0.79	1.17	1.19	1.17	1.20	1.09	0.86	0.84	1.07	1.14	1.11
7:00	1.53	1.52	1.75	1.31	1.48	1.67	1.54	1.68	1.53	1.34	1.27	1.42	1.46	1.59
8:00	1.95	1.95	2.29	1.92	1.89	1.89	1.84	1.97	1.87	1.91	1.91	1.74	1.79	1.82
9:00	2.03	2.03	2.75	2.44	1.90	1.99	1.84	1.93	1.93	2.52	2.27	1.91	1.81	1.88
10:00	1.87	2.03	2.85	2.51	1.88	1.91	1.72	1.77	1.86	2.55	2.33	1.81	1.76	1.84
11:00	1.77	1.81	2.71	2.35	1.81	1.72	1.67	1.58	1.66	2.43	2.25	1.65	1.56	1.75
12:00	1.58	1.60	2.40	2.09	1.65	1.66	1.59	1.52	1.55	2.23	2.06	1.51	1.50	1.64
13:00	1.48	1.47	2.22	1.90	1.64	1.57	1.54	1.45	1.50	2.10	1.91	1.48	1.35	1.48
14:00	1.37	1.35	2.03	1.76	1.52	1.38	1.44	1.43	1.43	2.12	1.85	1.38	1.30	1.44
15:00	1.33	1.30	1.87	1.71	1.46	1.36	1.40	1.34	1.41	2.05	1.68	1.33	1.32	1.38
16:00	1.30	1.31	1.84	1.63	1.50	1.41	1.39	1.32	1.36	1.86	1.71	1.33	1.31	1.40
17:00	1.35	1.39	1.71	1.66	1.49	1.43	1.50	1.44	1.37	1.79	1.72	1.32	1.33	1.46
18:00	1.44	1.45	1.71	1.64	1.52	1.50	1.51	1.54	1.37	1.77	1.72	1.41	1.48	1.54
19:00	1.51	1.48	1.70	1.68	1.70	1.63	1.57	1.59	1.46	1.78	1.75	1.52	1.58	1.65
20:00	1.53	1.51	1.65	1.78	1.78	1.75	1.64	1.63	1.43	1.74	1.81	1.59	1.65	1.74
21:00	1.58	1.52	1.57	1.73	1.75	1.66	1.63	1.55	1.43	1.45	1.66	1.58	1.62	1.73
22:00	1.46	1.54	1.43	1.51	1.56	1.53	1.53	1.38	1.36	1.29	1.45	1.42	1.47	1.56
23:00	1.30	1.33	1.32	1.18	1.32	1.28	1.41	1.23	1.22	1.23	1.25	1.20	1.28	1.23
Average	1.36	1.34	1.64	1.50	1.39	1.40	1.37	1.37	1.31	1.56	1.51	1.30	1.30	1.38
Median	1.39	1.42	1.69	1.64	1.51	1.45	1.49	1.43	1.39	1.74	1.69	1.37	1.36	1.46
Max Hr. Mean	2.03	2.03	2.85	2.51	1.90	1.99	1.84	1.97	1.93	2.55	2.33	1.91	1.81	1.88
Min Hr. Mean	0.68	0.59	0.60	0.60	0.58	0.70	0.66	0.72	0.64	0.59	0.58	0.61	0.63	0.67
Inst. Max	2.06	2.10	2.91	2.59	2.00	2.04	1.93	2.04	1.98	2.65	2.45	1.97	1.86	1.92
Inst. Min	0.66	0.56	0.59	0.58	0.57	0.67	0.65	0.71	0.64	0.58	0.57	0.59	0.61	0.66

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.05	4.81	4.83	4.96	4.86	4.82	4.88	4.85	4.71	4.79	4.87	4.87	4.76	4.77
1:00	4.69	4.49	4.57	4.50	4.37	4.48	4.57	4.40	4.41	4.49	4.72	4.33	4.36	4.52
2:00	4.39	4.14	4.30	4.28	4.26	4.13	4.22	4.36	4.32	4.26	4.41	4.28	4.21	4.26
3:00	4.28	4.11	4.13	4.19	4.16	4.19	4.18	4.13	4.16	4.23	4.48	4.16	4.27	4.18
4:00	4.26	4.24	4.05	4.10	4.28	4.18	4.31	4.27	4.22	4.07	4.10	4.23	4.20	4.22
5:00	4.84	4.47	4.24	4.17	4.56	4.64	4.65	4.57	4.52	4.12	4.16	4.54	4.56	4.57
6:00	5.15	5.02	4.61	4.43	4.99	4.93	5.00	5.02	4.86	4.58	4.51	4.96	5.01	4.91
7:00	5.45	5.44	5.38	5.25	5.43	5.56	5.47	5.46	5.47	5.38	5.09	5.51	5.45	5.45
8:00	5.88	5.87	5.99	5.80	5.86	5.73	5.70	5.78	5.75	5.98	5.77	5.79	5.68	5.70
9:00	5.93	5.97	6.27	6.12	5.81	5.92	5.76	5.90	5.90	6.27	6.10	5.82	5.78	5.71
10:00	5.72	5.93	6.25	6.16	5.78	5.83	5.62	5.70	5.85	6.15	6.11	5.76	5.75	5.60
11:00	5.71	5.66	6.23	6.05	5.72	5.53	5.56	5.48	5.54	6.16	5.98	5.60	5.66	5.60
12:00	5.63	5.52	6.10	6.00	5.64	5.53	5.40	5.40	5.50	6.09	5.91	5.51	5.45	5.51
13:00	5.42	5.41	6.05	5.77	5.55	5.48	5.46	5.34	5.43	6.02	5.95	5.40	5.32	5.30
14:00	5.32	5.28	5.79	5.68	5.39	5.27	5.24	5.28	5.23	5.91	5.83	5.30	5.26	5.24
15:00	5.21	5.22	5.67	5.62	5.25	5.29	5.20	5.21	5.32	5.88	5.55	5.25	5.30	5.16
16:00	5.19	5.23	5.67	5.58	5.37	5.39	5.24	5.16	5.29	5.72	5.64	5.27	5.23	5.23
17:00	5.34	5.27	5.61	5.60	5.32	5.42	5.29	5.34	5.21	5.60	5.63	5.25	5.19	5.37
18:00	5.37	5.32	5.61	5.61	5.35	5.49	5.37	5.41	5.30	5.63	5.70	5.41	5.42	5.45
19:00	5.46	5.34	5.56	5.72	5.53	5.64	5.48	5.44	5.41	5.58	5.70	5.57	5.60	5.52
20:00	5.52	5.42	5.54	5.74	5.54	5.68	5.37	5.45	5.34	5.51	5.83	5.61	5.58	5.56
21:00	5.46	5.38	5.42	5.78	5.51	5.55	5.44	5.49	5.32	5.43	5.61	5.58	5.53	5.60
22:00	5.38	5.32	5.31	5.48	5.38	5.42	5.40	5.23	5.28	5.24	5.32	5.44	5.37	5.43
23:00	5.22	5.23	5.24	5.16	5.17	5.08	5.30	5.17	5.06	5.09	5.22	5.18	5.16	5.08
Average	5.24	5.17	5.35	5.32	5.21	5.22	5.17	5.16	5.14	5.34	5.34	5.19	5.17	5.16
Median	5.34	5.32	5.54	5.58	5.38	5.43	5.33	5.30	5.30	5.53	5.61	5.35	5.32	5.31
Max Hr. Mean	5.93	5.97	6.27	6.16	5.86	5.92	5.76	5.90	5.90	6.27	6.11	5.82	5.78	5.71
Min Hr. Mean	4.26	4.11	4.05	4.10	4.16	4.13	4.18	4.13	4.16	4.07	4.10	4.16	4.20	4.18
Inst. Max	6.01	6.07	6.46	6.23	5.98	6.02	5.97	5.94	5.99	6.34	6.28	5.92	5.87	5.77
Inst. Min	4.19	3.99	3.95	4.04	4.11	4.07	4.04	4.07	4.10	3.99	4.04	4.08	4.11	4.15

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW170111

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.07	3.88	3.92	3.92	3.64	3.99	3.94	4.16	3.84	3.92	3.99	3.72	3.73	3.86
1:00	3.61	3.40	3.61	3.55	3.25	3.68	3.58	3.84	3.49	3.57	3.70	3.35	3.33	3.54
2:00	3.27	3.14	3.35	3.25	3.02	3.33	3.27	3.49	3.26	3.28	3.34	3.12	3.08	3.28
3:00	3.18	2.95	3.13	3.07	2.90	3.27	3.16	3.38	3.12	3.06	3.11	3.01	3.01	3.20
4:00	3.27	3.09	3.04	3.00	3.08	3.42	3.30	3.51	3.25	2.99	2.93	3.09	3.09	3.31
5:00	3.63	3.50	3.24	3.10	3.62	3.82	3.75	3.83	3.61	3.13	3.15	3.49	3.56	3.65
6:00	4.08	4.08	3.74	3.43	4.15	4.24	4.15	4.20	4.02	3.55	3.53	3.91	4.05	4.05
7:00	4.71	4.69	5.19	4.31	4.59	4.92	4.71	5.02	4.69	4.32	4.31	4.43	4.56	4.82
8:00	5.29	5.29	5.83	5.27	5.17	5.26	5.19	5.39	5.21	5.13	5.27	4.94	5.10	5.16
9:00	5.40	5.37	6.46	6.02	5.25	5.34	5.14	5.23	5.24	6.06	5.74	5.24	5.08	5.26
10:00	5.24	5.40	6.62	6.12	5.21	5.25	5.00	5.05	5.14	6.19	5.83	5.10	4.99	5.24
11:00	5.04	5.15	6.41	5.91	5.10	5.06	4.93	4.80	4.91	5.96	5.77	4.87	4.65	5.08
12:00	4.70	4.80	5.96	5.47	4.84	4.93	4.87	4.72	4.71	5.65	5.47	4.62	4.63	4.90
13:00	4.61	4.59	5.66	5.26	4.88	4.77	4.70	4.60	4.65	5.49	5.18	4.62	4.38	4.70
14:00	4.43	4.42	5.50	5.04	4.72	4.47	4.63	4.58	4.62	5.58	5.13	4.46	4.32	4.62
15:00	4.40	4.32	5.27	4.98	4.68	4.41	4.57	4.41	4.53	5.48	4.94	4.39	4.33	4.55
16:00	4.35	4.35	5.21	4.84	4.68	4.48	4.52	4.41	4.42	5.22	4.97	4.37	4.34	4.55
17:00	4.38	4.49	4.99	4.89	4.71	4.51	4.73	4.58	4.49	5.16	4.99	4.37	4.41	4.60
18:00	4.56	4.59	4.98	4.84	4.74	4.61	4.71	4.74	4.45	5.08	4.94	4.46	4.60	4.72
19:00	4.65	4.67	4.99	4.84	5.01	4.79	4.78	4.84	4.57	5.15	5.00	4.61	4.72	4.90
20:00	4.67	4.68	4.90	5.04	5.16	5.01	5.00	4.91	4.55	5.10	5.05	4.74	4.87	5.08
21:00	4.78	4.74	4.81	4.92	5.13	4.90	4.93	4.72	4.55	4.53	4.87	4.73	4.84	5.04
22:00	4.59	4.80	4.57	4.63	4.81	4.71	4.73	4.49	4.42	4.30	4.60	4.46	4.61	4.77
23:00	4.33	4.39	4.36	4.07	4.39	4.37	4.52	4.20	4.22	4.23	4.21	4.11	4.31	4.24
Average	4.38	4.37	4.82	4.57	4.45	4.48	4.45	4.46	4.33	4.67	4.58	4.26	4.27	4.46
Median	4.48	4.52	4.95	4.86	4.71	4.56	4.68	4.55	4.48	5.04	4.90	4.45	4.41	4.64
Max Hr. Mean	5.40	5.40	6.62	6.12	5.25	5.34	5.19	5.39	5.24	6.19	5.83	5.24	5.10	5.26
Min Hr. Mean	3.18	2.95	3.04	3.00	2.90	3.27	3.16	3.38	3.12	2.99	2.93	3.01	3.01	3.20
Inst. Max	5.43	5.47	6.70	6.20	5.32	5.38	5.30	5.49	5.34	6.30	6.15	5.31	5.20	5.31
Inst. Min	3.12	2.92	3.02	2.97	2.89	3.23	3.15	3.37	3.10	2.97	2.90	2.96	2.98	3.17

All Values in Inches

FLOW SERVICES GROUP

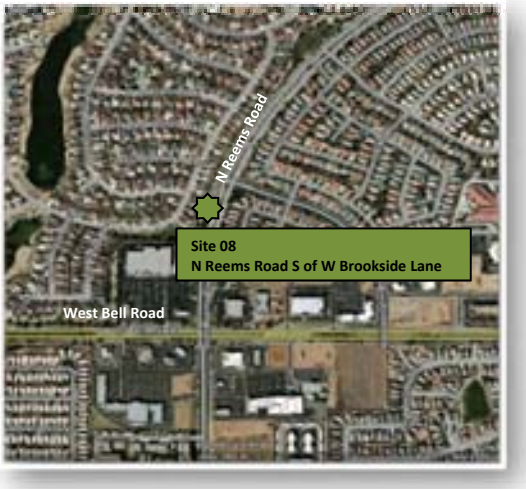
Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 08
Address: N Reems Road S of W Brookside Lane
MH ID# SSMH4N1WSW320090

Date: 6/9/2008
GPS: 33.382881N -112.233747W

Overview

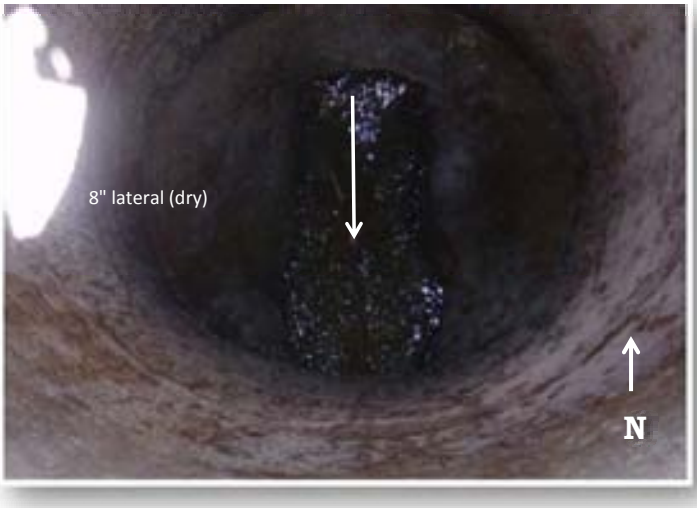


Street Level

Meter Details

Meter Type 2150
Serial # 205F00936
Sensor Serial # 205K01553
Telemetry None
Sample Rate 5 min

Down Manhole



Pipe Details and Manhole Condition

Pipe Size (in) Vert. 21" Horiz. 21"
Laterals 1
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris Yes - towels & TP
Grease No
Pests No

Hydraulics:
Slow to moderate flow conditions

Comments:
Bench area corroded. High H2S levels
Some debris / rock in bench area. Removed debris and rock for installation of equipment

Photos
MH #SSMH4N1WSW320090
Site #08

Site ID

Down Manhole

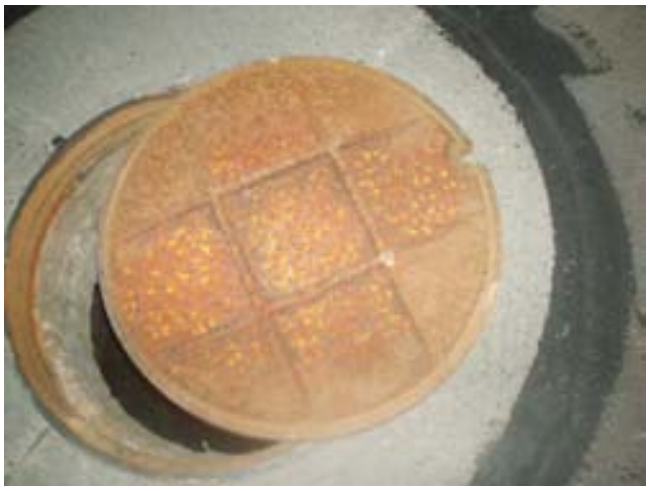
21” Influent

21” Effluent

8” Lateral (Dry)

Manhole Cover Top

Photos
MH #SSMH4N1WSW320090
Site #08



Manhole Cover Bottom

Location Summary

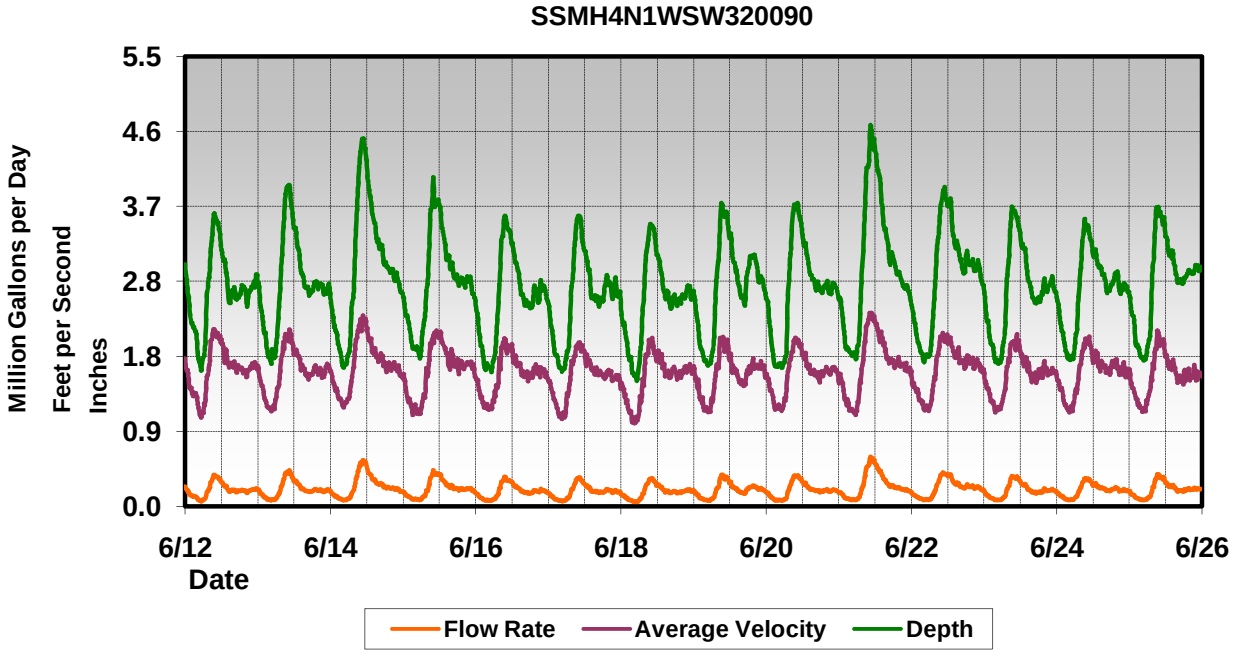
Site	**SSMH4N1WSW320090**
Address	**Reems Road at Brookside Lane**
Diameter	**21** Inches
GPS	**33.382881N -112.233747W**

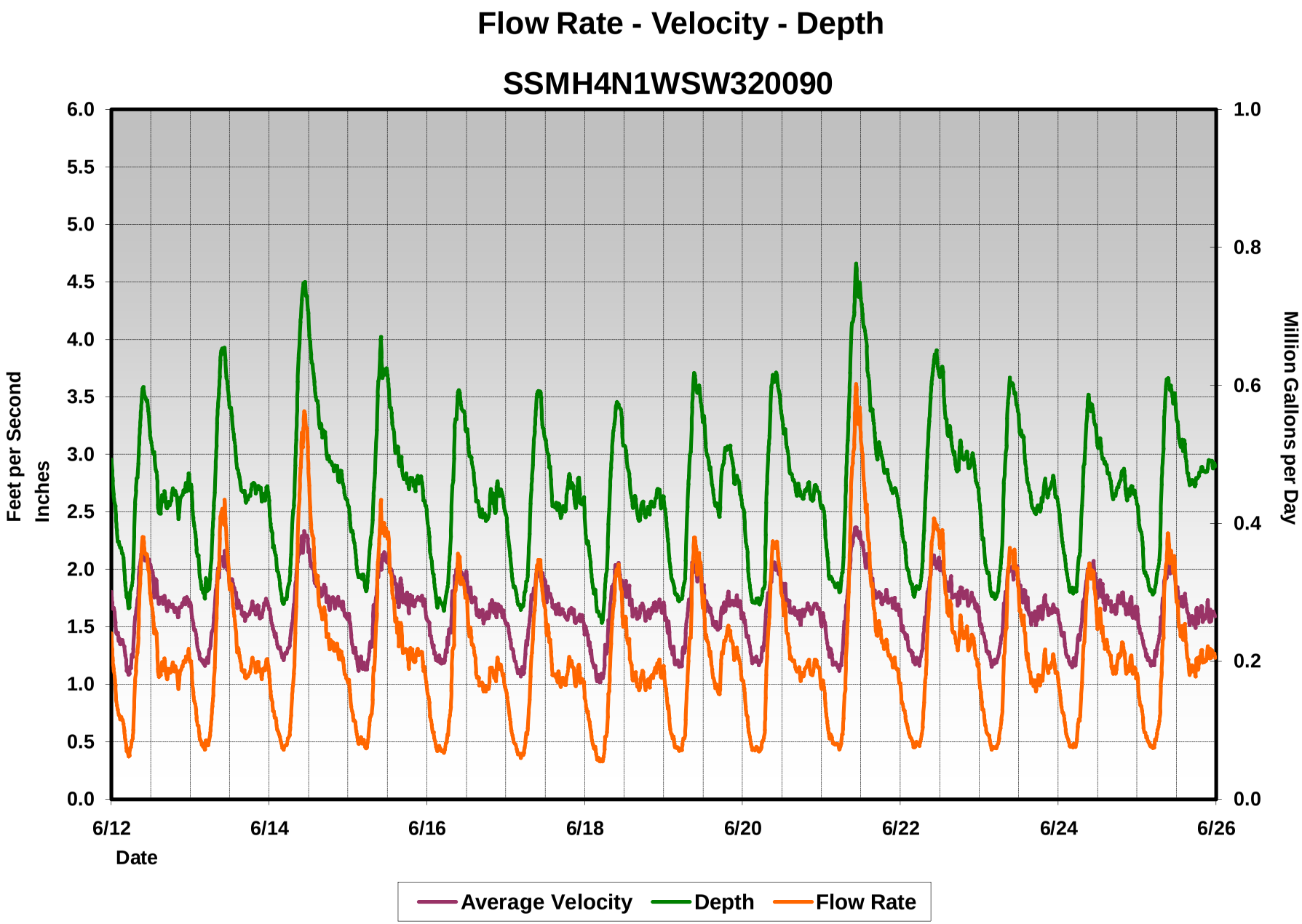
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	2.70
Maximum	4.66
Minimum	1.54
Max d/D	22.2%

Flow velocity	
	Feet per Second
Average	1.64
Maximum	2.36
Minimum	1.02

Flow Rate	
	Million Gallons per Day
Average	0.20
Maximum	0.60
Minimum	0.06
Peak Factor	2.94



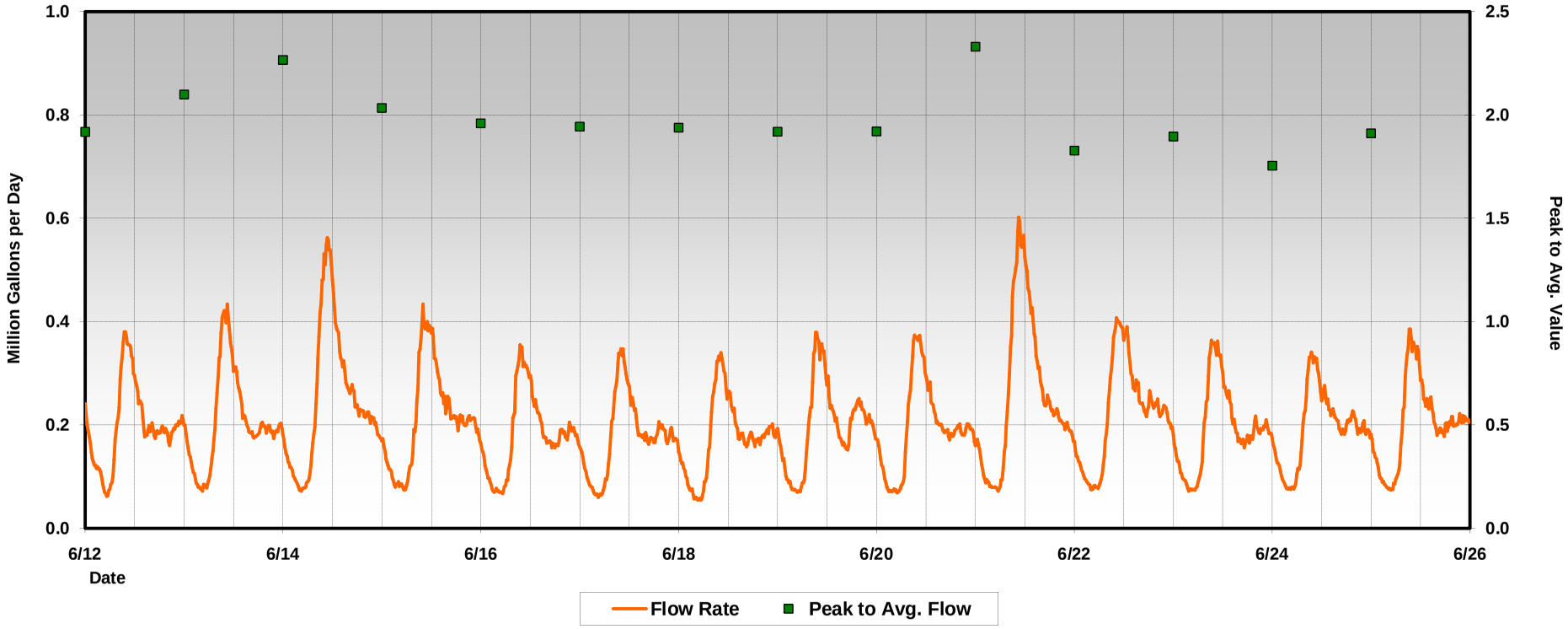

Flow Rate - Velocity - Depth
SSMH4N1WSW320090
Feet per Second
Inches
Million Gallons per Day
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
1.0
0.8
0.6
0.4
0.2
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

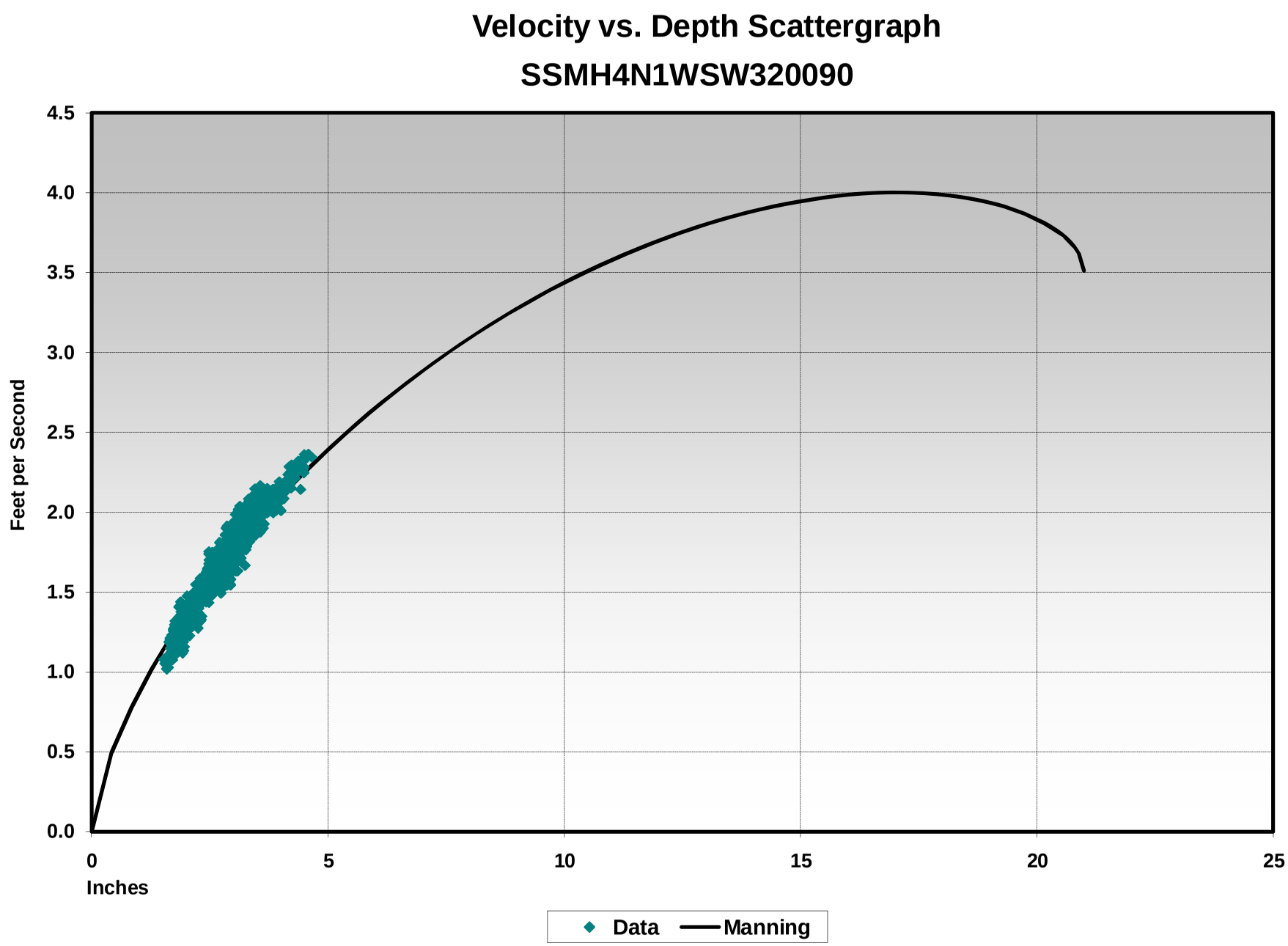
Peak to Average Flow Rate

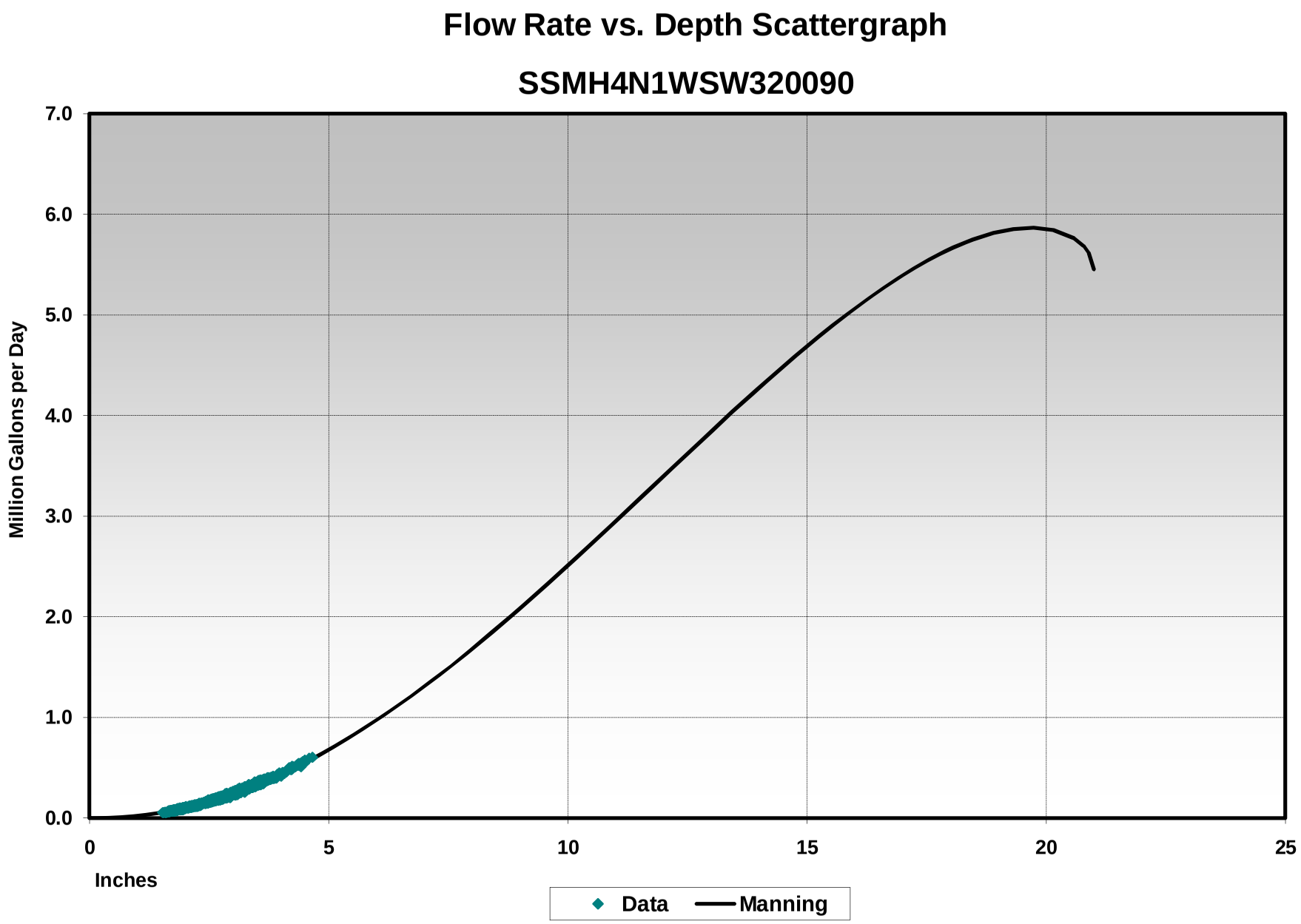
Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.92	2.10	2.27	2.03	1.96	1.94	1.94	1.92	1.92	2.33	1.83	1.89	1.75	1.91




Velocity vs. Depth Scattergraph
SSMH4N1WSW320090
Feet per Second
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH4N1WSW320090
Million Gallons per Day
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.21	0.19	0.16	0.16	0.15	0.15	0.14	0.17	0.16	0.17	0.15	0.16	0.16	0.16
1:00	0.16	0.14	0.13	0.12	0.11	0.11	0.11	0.13	0.12	0.13	0.12	0.12	0.13	0.13
2:00	0.12	0.11	0.11	0.10	0.09	0.09	0.08	0.09	0.09	0.10	0.10	0.10	0.10	0.10
3:00	0.11	0.08	0.09	0.08	0.07	0.07	0.07	0.08	0.07	0.09	0.09	0.08	0.08	0.08
4:00	0.08	0.08	0.07	0.09	0.07	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
5:00	0.07	0.08	0.08	0.08	0.07	0.07	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
6:00	0.09	0.11	0.10	0.10	0.10	0.09	0.09	0.10	0.09	0.10	0.09	0.10	0.11	0.10
7:00	0.17	0.19	0.17	0.15	0.16	0.16	0.16	0.18	0.19	0.18	0.15	0.18	0.19	0.18
8:00	0.26	0.30	0.31	0.23	0.26	0.25	0.26	0.27	0.29	0.32	0.25	0.28	0.27	0.29
9:00	0.36	0.41	0.45	0.36	0.34	0.32	0.32	0.37	0.37	0.48	0.35	0.36	0.33	0.37
10:00	0.36	0.41	0.54	0.40	0.32	0.34	0.33	0.35	0.37	0.57	0.40	0.35	0.33	0.35
11:00	0.33	0.36	0.54	0.39	0.31	0.29	0.28	0.32	0.33	0.55	0.39	0.33	0.29	0.33
12:00	0.28	0.31	0.44	0.37	0.27	0.26	0.26	0.27	0.28	0.50	0.38	0.28	0.26	0.27
13:00	0.24	0.27	0.37	0.31	0.24	0.23	0.22	0.23	0.25	0.44	0.33	0.26	0.24	0.25
14:00	0.19	0.22	0.32	0.27	0.21	0.18	0.18	0.20	0.21	0.37	0.28	0.22	0.23	0.24
15:00	0.19	0.20	0.28	0.24	0.18	0.18	0.18	0.17	0.20	0.31	0.27	0.18	0.21	0.21
16:00	0.19	0.18	0.27	0.24	0.17	0.17	0.16	0.16	0.19	0.26	0.24	0.17	0.19	0.19
17:00	0.18	0.18	0.25	0.22	0.16	0.17	0.18	0.18	0.18	0.25	0.22	0.17	0.19	0.18
18:00	0.19	0.19	0.23	0.20	0.16	0.17	0.17	0.22	0.18	0.23	0.25	0.17	0.21	0.20
19:00	0.19	0.20	0.22	0.21	0.19	0.20	0.17	0.24	0.19	0.22	0.24	0.19	0.22	0.21
20:00	0.17	0.19	0.22	0.20	0.18	0.19	0.18	0.24	0.19	0.21	0.23	0.20	0.20	0.20
21:00	0.19	0.18	0.21	0.21	0.19	0.17	0.19	0.21	0.19	0.20	0.23	0.19	0.19	0.21
22:00	0.20	0.19	0.20	0.21	0.19	0.18	0.20	0.21	0.20	0.20	0.23	0.20	0.20	0.21
23:00	0.21	0.20	0.18	0.18	0.17	0.17	0.18	0.19	0.18	0.18	0.20	0.19	0.19	0.21
Average	0.20	0.21	0.25	0.21	0.18	0.18	0.18	0.20	0.19	0.26	0.22	0.19	0.19	0.20
Median	0.19	0.19	0.22	0.21	0.18	0.18	0.18	0.20	0.19	0.22	0.23	0.18	0.20	0.20
Max Hr. Mean	0.36	0.41	0.54	0.40	0.34	0.34	0.33	0.37	0.37	0.57	0.40	0.36	0.33	0.37
Min Hr. Mean	0.07	0.08	0.07	0.08	0.07	0.06	0.06	0.07	0.07	0.08	0.08	0.08	0.08	0.08
Inst. Max	0.38	0.43	0.56	0.43	0.36	0.35	0.34	0.38	0.37	0.60	0.41	0.36	0.34	0.39
Inst. Min	0.06	0.07	0.07	0.07	0.07	0.06	0.06	0.07	0.07	0.07	0.08	0.07	0.08	0.07

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.71	1.64	1.61	1.56	1.55	1.52	1.46	1.63	1.58	1.56	1.53	1.54	1.54	1.57
1:00	1.51	1.48	1.47	1.34	1.38	1.38	1.35	1.49	1.44	1.45	1.43	1.42	1.43	1.41
2:00	1.39	1.32	1.38	1.27	1.27	1.26	1.21	1.30	1.30	1.29	1.35	1.30	1.29	1.30
3:00	1.37	1.21	1.30	1.17	1.22	1.14	1.10	1.23	1.20	1.22	1.28	1.22	1.20	1.23
4:00	1.22	1.18	1.23	1.18	1.20	1.10	1.05	1.18	1.22	1.17	1.19	1.20	1.18	1.18
5:00	1.11	1.23	1.28	1.14	1.23	1.12	1.08	1.19	1.19	1.14	1.19	1.21	1.22	1.22
6:00	1.24	1.39	1.38	1.27	1.38	1.35	1.26	1.34	1.35	1.29	1.26	1.34	1.41	1.36
7:00	1.58	1.63	1.63	1.44	1.56	1.61	1.52	1.64	1.68	1.61	1.51	1.61	1.63	1.58
8:00	1.89	1.92	1.97	1.69	1.84	1.80	1.83	1.84	1.85	1.92	1.78	1.85	1.84	1.85
9:00	2.14	2.09	2.17	2.00	2.00	1.93	1.97	2.04	2.03	2.23	2.00	2.00	1.99	2.07
10:00	2.11	2.10	2.25	2.08	1.95	1.96	1.99	1.99	2.01	2.34	2.07	2.00	2.02	2.02
11:00	2.06	2.01	2.28	2.10	1.93	1.93	1.84	1.93	1.94	2.30	2.06	1.98	1.91	1.97
12:00	1.99	1.89	2.10	2.08	1.85	1.81	1.85	1.74	1.85	2.22	2.02	1.84	1.83	1.80
13:00	1.85	1.84	2.00	1.97	1.76	1.77	1.78	1.69	1.76	2.09	1.95	1.76	1.79	1.72
14:00	1.74	1.73	1.90	1.89	1.75	1.69	1.67	1.62	1.67	2.05	1.85	1.72	1.73	1.73
15:00	1.73	1.66	1.82	1.75	1.63	1.65	1.63	1.52	1.64	1.91	1.87	1.59	1.72	1.63
16:00	1.72	1.59	1.81	1.83	1.61	1.63	1.60	1.50	1.62	1.78	1.77	1.59	1.66	1.55
17:00	1.69	1.60	1.78	1.75	1.58	1.63	1.68	1.57	1.57	1.78	1.76	1.56	1.65	1.54
18:00	1.68	1.65	1.71	1.72	1.60	1.58	1.61	1.67	1.61	1.73	1.80	1.64	1.74	1.61
19:00	1.65	1.67	1.74	1.73	1.67	1.63	1.61	1.75	1.66	1.76	1.77	1.64	1.76	1.64
20:00	1.62	1.66	1.71	1.71	1.66	1.63	1.63	1.71	1.65	1.73	1.74	1.70	1.67	1.57
21:00	1.68	1.59	1.71	1.75	1.64	1.55	1.69	1.71	1.65	1.72	1.74	1.63	1.66	1.63
22:00	1.72	1.67	1.68	1.74	1.65	1.57	1.70	1.71	1.69	1.69	1.71	1.66	1.67	1.59
23:00	1.73	1.72	1.59	1.67	1.59	1.56	1.66	1.65	1.63	1.66	1.67	1.64	1.64	1.61
Average	1.67	1.64	1.73	1.66	1.60	1.58	1.57	1.61	1.62	1.74	1.68	1.61	1.63	1.60
Median	1.69	1.65	1.72	1.72	1.62	1.61	1.63	1.66	1.64	1.74	1.75	1.63	1.68	1.59
Max Hr. Mean	2.14	2.10	2.28	2.10	2.00	1.96	1.99	2.04	2.03	2.34	2.07	2.00	2.02	2.07
Min Hr. Mean	1.11	1.18	1.23	1.14	1.20	1.10	1.05	1.18	1.19	1.14	1.19	1.20	1.18	1.18
Inst. Max	2.17	2.16	2.33	2.15	2.05	2.00	2.06	2.07	2.06	2.36	2.12	2.10	2.07	2.15
Inst. Min	1.09	1.16	1.21	1.12	1.18	1.07	1.02	1.15	1.17	1.12	1.16	1.15	1.15	1.16

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW320090

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	2.81	2.66	2.45	2.49	2.39	2.39	2.32	2.54	2.49	2.53	2.38	2.49	2.48	2.48
1:00	2.48	2.35	2.21	2.31	2.08	2.11	2.16	2.23	2.15	2.27	2.18	2.19	2.22	2.28
2:00	2.22	2.10	2.04	2.12	1.86	1.87	1.88	1.95	1.82	1.97	1.98	1.99	2.03	1.98
3:00	2.14	1.87	1.86	1.94	1.71	1.75	1.74	1.82	1.71	1.91	1.87	1.85	1.85	1.89
4:00	1.86	1.81	1.72	1.94	1.71	1.67	1.61	1.75	1.73	1.86	1.80	1.77	1.82	1.80
5:00	1.71	1.84	1.77	1.85	1.69	1.72	1.58	1.75	1.72	1.83	1.84	1.78	1.83	1.83
6:00	1.90	2.08	1.97	2.06	1.89	1.89	1.89	1.93	1.83	1.99	1.95	1.99	2.10	2.01
7:00	2.58	2.64	2.52	2.42	2.41	2.43	2.46	2.61	2.65	2.64	2.44	2.59	2.64	2.59
8:00	3.02	3.32	3.26	2.96	3.07	3.00	3.06	3.16	3.30	3.43	3.06	3.21	3.14	3.33
9:00	3.49	3.83	4.04	3.67	3.47	3.44	3.36	3.64	3.66	4.11	3.53	3.60	3.46	3.64
10:00	3.49	3.88	4.43	3.82	3.44	3.52	3.42	3.58	3.67	4.50	3.81	3.58	3.39	3.56
11:00	3.34	3.60	4.38	3.72	3.33	3.24	3.24	3.45	3.48	4.44	3.78	3.44	3.23	3.48
12:00	3.07	3.39	4.03	3.58	3.15	3.07	3.04	3.24	3.24	4.25	3.73	3.23	3.10	3.24
13:00	2.93	3.15	3.73	3.31	2.97	2.89	2.84	2.98	3.10	4.03	3.50	3.13	3.00	3.10
14:00	2.58	2.88	3.50	3.08	2.79	2.57	2.60	2.82	2.87	3.64	3.21	2.84	2.92	3.05
15:00	2.58	2.73	3.30	2.99	2.58	2.54	2.60	2.62	2.79	3.36	3.16	2.67	2.82	2.85
16:00	2.61	2.67	3.19	2.90	2.49	2.52	2.44	2.53	2.69	3.13	2.99	2.53	2.68	2.75
17:00	2.56	2.61	3.07	2.80	2.47	2.52	2.55	2.66	2.69	3.03	2.86	2.52	2.66	2.75
18:00	2.64	2.68	2.96	2.73	2.44	2.58	2.49	2.97	2.63	2.98	3.05	2.52	2.73	2.80
19:00	2.67	2.74	2.90	2.78	2.61	2.77	2.51	3.05	2.69	2.85	2.97	2.65	2.82	2.87
20:00	2.52	2.70	2.89	2.73	2.57	2.72	2.57	3.03	2.69	2.80	2.97	2.70	2.76	2.86
21:00	2.63	2.68	2.81	2.78	2.67	2.58	2.59	2.82	2.63	2.69	2.91	2.69	2.65	2.88
22:00	2.71	2.62	2.77	2.76	2.67	2.70	2.69	2.79	2.72	2.69	2.92	2.77	2.71	2.94
23:00	2.76	2.68	2.62	2.57	2.57	2.59	2.58	2.66	2.63	2.58	2.73	2.64	2.65	2.90
Average	2.64	2.73	2.93	2.76	2.54	2.55	2.51	2.69	2.65	2.98	2.82	2.64	2.65	2.74
Median	2.64	2.69	2.90	2.77	2.54	2.57	2.55	2.76	2.68	2.86	2.94	2.63	2.71	2.85
Max Hr. Mean	3.49	3.88	4.43	3.82	3.47	3.52	3.42	3.64	3.67	4.50	3.81	3.60	3.46	3.64
Min Hr. Mean	1.71	1.81	1.72	1.85	1.69	1.67	1.58	1.75	1.71	1.83	1.80	1.77	1.82	1.80
Inst. Max	3.59	3.93	4.50	4.02	3.56	3.55	3.45	3.71	3.71	4.66	3.90	3.67	3.52	3.66
Inst. Min	1.66	1.75	1.70	1.81	1.64	1.65	1.54	1.72	1.70	1.80	1.76	1.74	1.79	1.78

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 09
Address: Bullard Avenue at Charter Oaks Road
MH ID# SSMH3N1WSW160002

Date: 6/9/2008
GPS: 33.354711N -112.223552W

Overview

Street Level

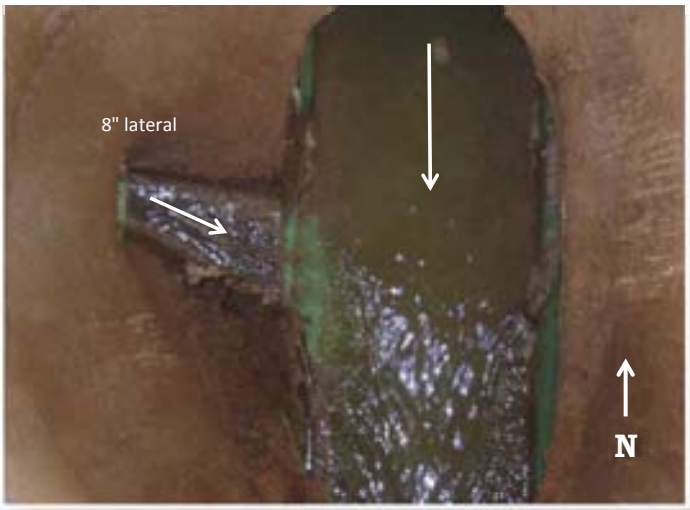
Meter Details

Meter Type	2150
Serial #	202E01460
Sensor Serial #	201C03029
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert. 24" Horiz. 24"
Laterals	1
Pipe Material	PVC
Surcharge Evidence	No
Height Above Crown (in)	0
Infiltration	No
Silt	No
Debris	No
Grease	No
Pests	No

Down Manhole



Hydraulics:
Moderate flow conditions

Comments:
Good flow monitoring site

Photos
MH #SSMH3N1WSW160002
Site #09

Site ID

Down Manhole

24” Influent

24” Effluent

8” Lateral

Manhole Cover Top

Photos
MH #SSMH3N1WSW160002
Site #09

Manhole Cover Bottom

Location Summary

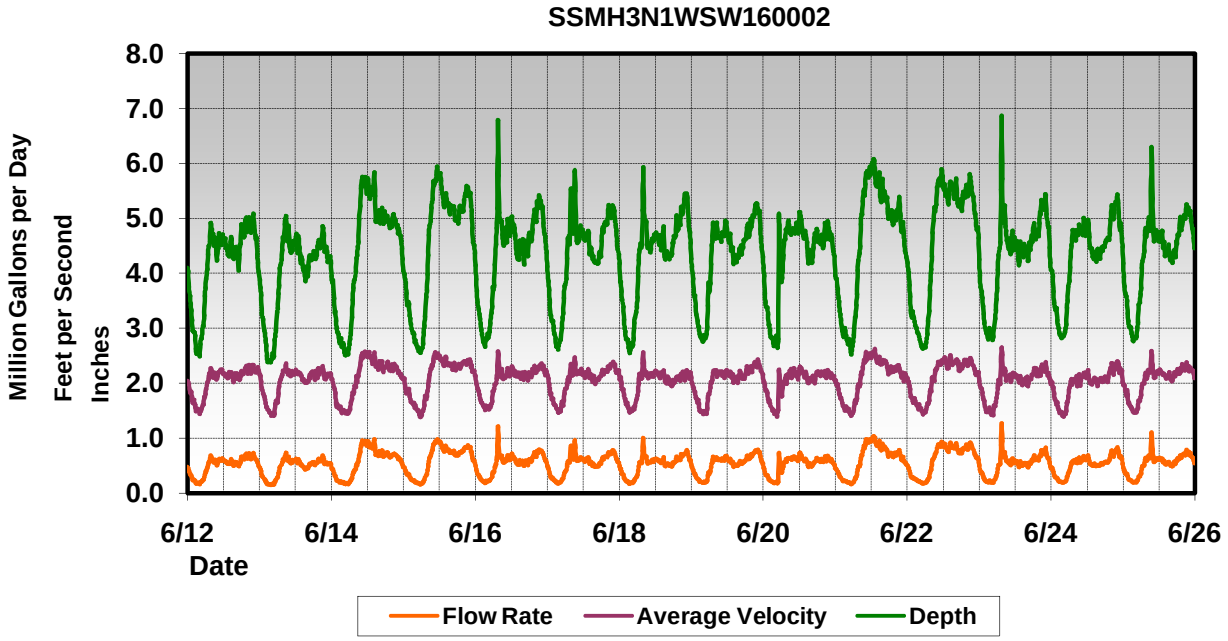
Site	**SSMH3N1WSW160002**
Address	**Bullard Ave and Charter Oaks Rd**
Diameter	**24** Inches
GPS	**33.354711N -112.223552W**

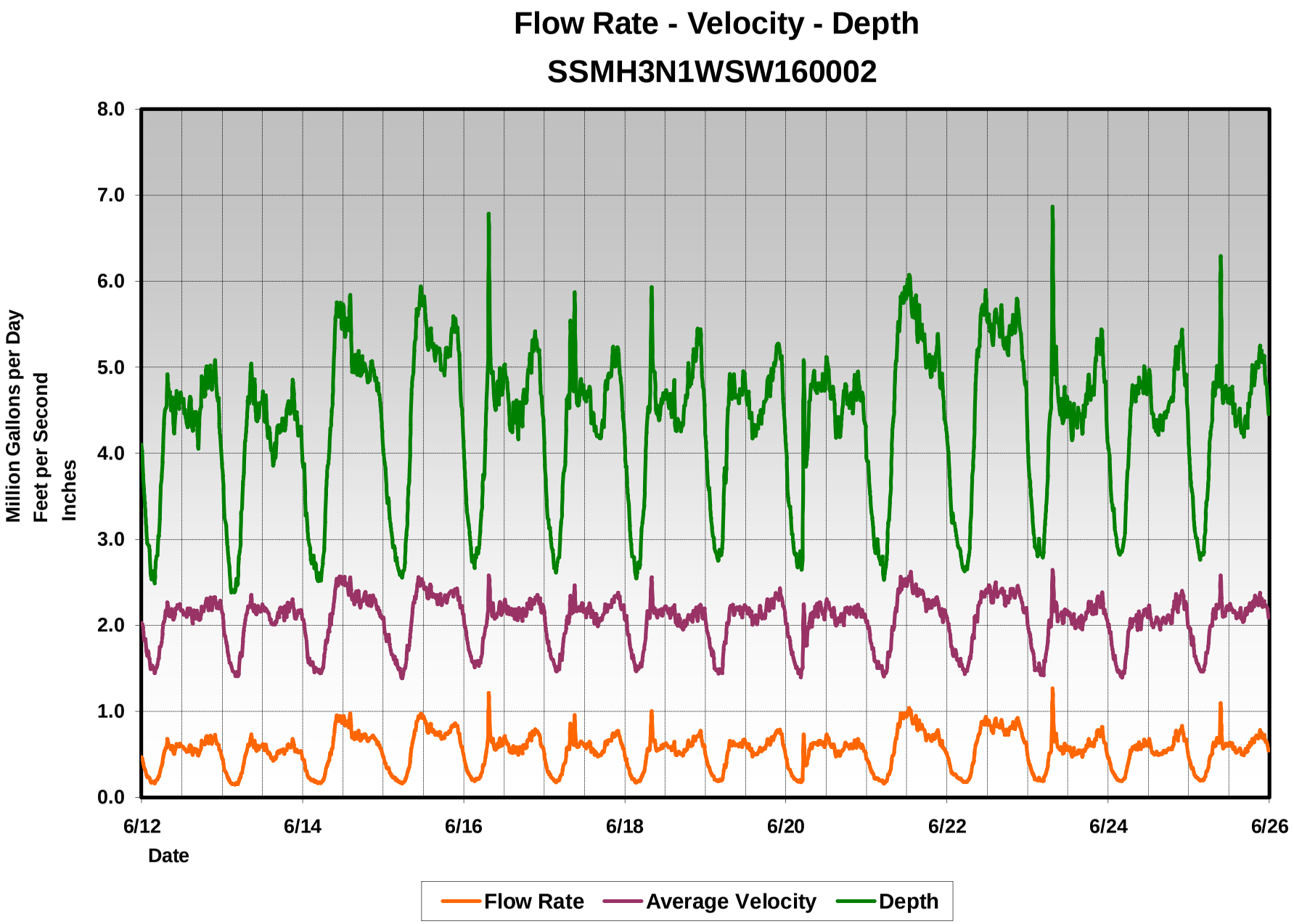
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.35
Maximum	6.87
Minimum	2.38
Max d/D	28.6%

Flow velocity	
	Feet per Second
Average	2.05
Maximum	2.64
Minimum	1.38

Flow Rate	
	Million Gallons per Day
Average	0.54
Maximum	1.27
Minimum	0.15
Peak Factor	2.34



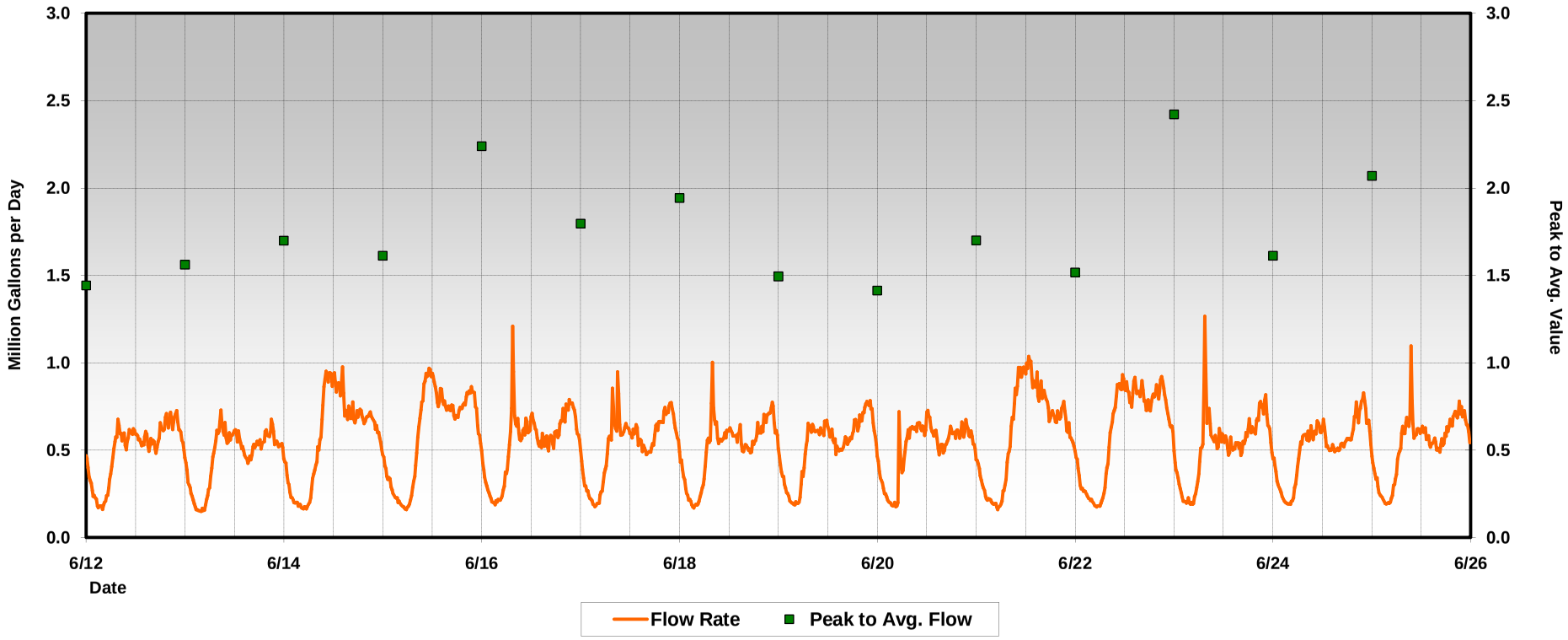

Flow Rate - Velocity - Depth
SSMH3N1WSW160002
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

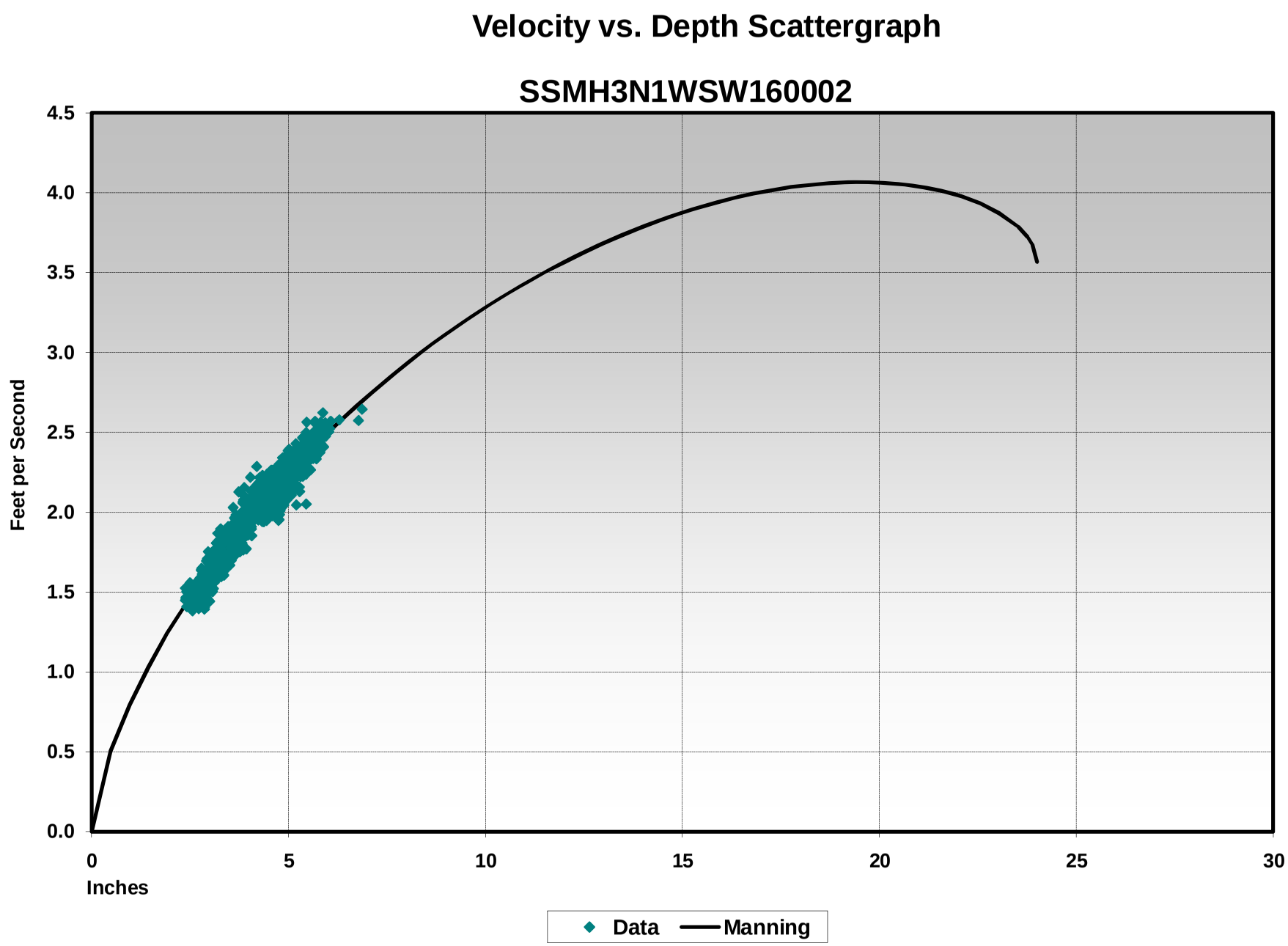
Peak to Average Flow Rate

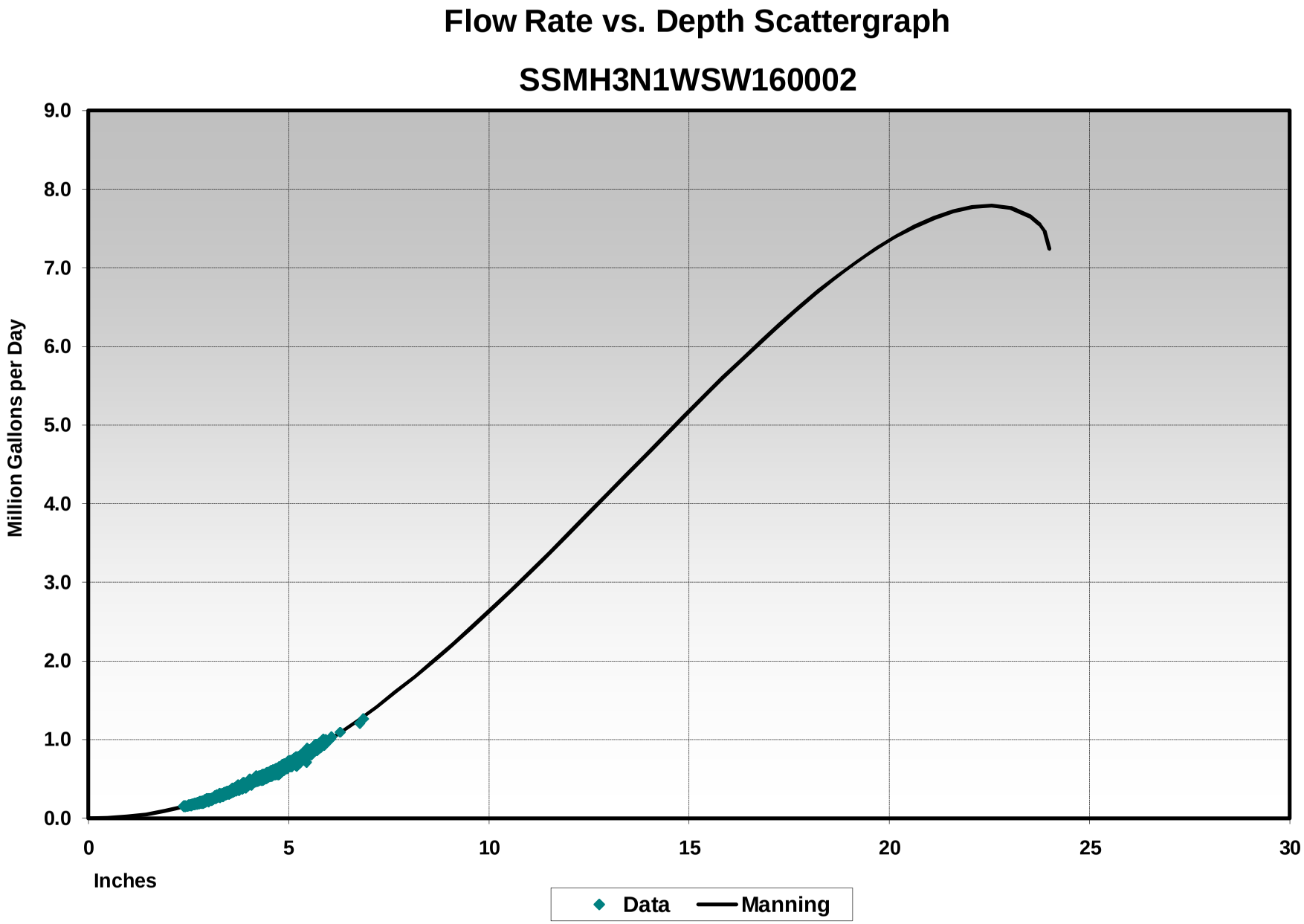
Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.44	1.56	1.70	1.61	2.24	1.80	1.94	1.49	1.41	1.70	1.52	2.42	1.61	2.07




Velocity vs. Depth Scattergraph
SSMH3N1WSW160002
Feet per Second
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WSW160002
Million Gallons per Day
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.42	0.40	0.42	0.43	0.41	0.42	0.44	0.44	0.41	0.43	0.45	0.42	0.42	0.41
1:00	0.29	0.27	0.28	0.34	0.29	0.28	0.30	0.32	0.29	0.32	0.30	0.30	0.30	0.31
2:00	0.22	0.19	0.21	0.26	0.22	0.22	0.22	0.24	0.23	0.24	0.26	0.21	0.23	0.23
3:00	0.18	0.16	0.19	0.22	0.20	0.18	0.18	0.20	0.19	0.22	0.22	0.21	0.20	0.20
4:00	0.19	0.16	0.17	0.19	0.22	0.21	0.19	0.20	0.19	0.19	0.20	0.19	0.20	0.21
5:00	0.27	0.23	0.17	0.17	0.29	0.30	0.27	0.28	0.47	0.17	0.18	0.27	0.29	0.29
6:00	0.43	0.37	0.22	0.19	0.44	0.46	0.45	0.44	0.42	0.23	0.20	0.46	0.48	0.45
7:00	0.59	0.54	0.38	0.30	0.88	0.64	0.61	0.62	0.58	0.39	0.33	0.90	0.57	0.59
8:00	0.60	0.65	0.50	0.53	0.67	0.66	0.77	0.62	0.63	0.58	0.54	0.69	0.58	0.65
9:00	0.55	0.62	0.72	0.74	0.57	0.75	0.58	0.61	0.63	0.78	0.71	0.57	0.59	0.80
10:00	0.59	0.56	0.92	0.91	0.63	0.60	0.56	0.61	0.64	0.93	0.86	0.54	0.62	0.60
11:00	0.61	0.58	0.92	0.94	0.62	0.63	0.60	0.64	0.62	0.95	0.88	0.59	0.62	0.62
12:00	0.58	0.59	0.90	0.90	0.68	0.60	0.61	0.60	0.71	0.98	0.86	0.56	0.62	0.62
13:00	0.55	0.56	0.85	0.78	0.59	0.62	0.58	0.57	0.60	0.95	0.79	0.51	0.51	0.58
14:00	0.58	0.49	0.85	0.81	0.55	0.55	0.60	0.50	0.58	0.89	0.88	0.51	0.51	0.53
15:00	0.53	0.45	0.72	0.75	0.56	0.51	0.51	0.51	0.51	0.84	0.83	0.53	0.50	0.54
16:00	0.54	0.49	0.72	0.74	0.54	0.48	0.52	0.56	0.51	0.82	0.84	0.51	0.52	0.51
17:00	0.53	0.53	0.69	0.71	0.56	0.52	0.51	0.56	0.59	0.74	0.76	0.57	0.54	0.56
18:00	0.63	0.54	0.71	0.71	0.59	0.62	0.56	0.64	0.60	0.71	0.76	0.63	0.56	0.61
19:00	0.67	0.58	0.67	0.75	0.68	0.66	0.62	0.65	0.60	0.68	0.83	0.61	0.62	0.67
20:00	0.67	0.59	0.69	0.80	0.71	0.71	0.66	0.69	0.62	0.70	0.84	0.70	0.71	0.70
21:00	0.67	0.62	0.69	0.84	0.76	0.74	0.69	0.76	0.62	0.73	0.87	0.75	0.76	0.74
22:00	0.65	0.54	0.63	0.79	0.73	0.72	0.75	0.75	0.60	0.61	0.73	0.74	0.75	0.70
23:00	0.55	0.53	0.56	0.59	0.59	0.59	0.61	0.59	0.54	0.55	0.63	0.57	0.62	0.61
Average	0.50	0.47	0.57	0.60	0.54	0.53	0.52	0.52	0.52	0.61	0.61	0.52	0.51	0.53
Median	0.56	0.53	0.67	0.73	0.58	0.57	0.56	0.57	0.58	0.68	0.73	0.54	0.55	0.57
Max Hr. Mean	0.67	0.65	0.92	0.94	0.88	0.75	0.77	0.76	0.71	0.98	0.88	0.90	0.76	0.80
Min Hr. Mean	0.18	0.16	0.17	0.17	0.20	0.18	0.18	0.20	0.19	0.17	0.18	0.19	0.20	0.20
Inst. Max	0.73	0.73	0.98	0.97	1.21	0.95	1.00	0.78	0.73	1.04	0.93	1.27	0.83	1.10
Inst. Min	0.16	0.15	0.16	0.16	0.19	0.18	0.17	0.19	0.18	0.16	0.18	0.19	0.19	0.19

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.96	2.05	2.02	2.00	2.00	2.02	2.05	1.99	1.97	2.01	2.01	1.95	1.96	1.94
1:00	1.76	1.78	1.73	1.87	1.76	1.76	1.82	1.79	1.76	1.80	1.76	1.73	1.70	1.76
2:00	1.60	1.57	1.57	1.70	1.61	1.61	1.64	1.62	1.61	1.63	1.67	1.51	1.55	1.59
3:00	1.51	1.47	1.51	1.61	1.55	1.50	1.50	1.48	1.49	1.55	1.58	1.49	1.44	1.49
4:00	1.50	1.42	1.48	1.53	1.57	1.54	1.52	1.46	1.46	1.50	1.55	1.44	1.43	1.49
5:00	1.68	1.59	1.46	1.42	1.68	1.68	1.63	1.63	1.93	1.43	1.46	1.64	1.64	1.67
6:00	1.94	1.85	1.59	1.49	1.93	1.96	1.95	1.93	1.87	1.57	1.55	1.94	1.99	1.93
7:00	2.16	2.14	1.85	1.71	2.35	2.14	2.17	2.17	2.06	1.82	1.76	2.38	2.03	2.12
8:00	2.14	2.25	2.05	2.00	2.19	2.19	2.30	2.17	2.14	2.07	2.03	2.23	2.04	2.19
9:00	2.13	2.20	2.27	2.29	2.10	2.29	2.14	2.20	2.20	2.31	2.19	2.10	2.05	2.33
10:00	2.19	2.16	2.50	2.49	2.18	2.19	2.16	2.18	2.22	2.48	2.34	2.08	2.12	2.14
11:00	2.22	2.18	2.54	2.49	2.18	2.22	2.17	2.18	2.13	2.50	2.38	2.16	2.15	2.20
12:00	2.15	2.20	2.52	2.44	2.25	2.16	2.20	2.18	2.27	2.51	2.42	2.13	2.14	2.21
13:00	2.14	2.17	2.44	2.34	2.15	2.20	2.14	2.16	2.16	2.51	2.32	2.06	2.00	2.17
14:00	2.17	2.07	2.43	2.40	2.16	2.14	2.18	2.04	2.12	2.42	2.44	2.01	2.06	2.11
15:00	2.12	2.01	2.32	2.34	2.13	2.09	2.04	2.06	2.04	2.37	2.37	2.04	2.00	2.14
16:00	2.11	2.08	2.35	2.29	2.13	2.04	2.07	2.15	2.08	2.39	2.40	2.03	2.06	2.07
17:00	2.10	2.17	2.26	2.30	2.12	2.09	1.99	2.10	2.10	2.28	2.30	2.11	2.06	2.18
18:00	2.19	2.16	2.34	2.31	2.14	2.20	2.03	2.24	2.17	2.24	2.29	2.20	2.07	2.19
19:00	2.28	2.20	2.25	2.33	2.24	2.22	2.09	2.22	2.18	2.25	2.39	2.18	2.17	2.26
20:00	2.25	2.22	2.28	2.39	2.24	2.26	2.12	2.27	2.19	2.27	2.36	2.21	2.25	2.28
21:00	2.26	2.20	2.31	2.39	2.29	2.34	2.12	2.35	2.16	2.26	2.41	2.28	2.31	2.30
22:00	2.26	2.12	2.19	2.36	2.31	2.31	2.21	2.34	2.15	2.12	2.25	2.26	2.32	2.24
23:00	2.23	2.16	2.11	2.19	2.20	2.21	2.15	2.21	2.10	2.14	2.18	2.11	2.19	2.18
Average	2.04	2.02	2.10	2.11	2.06	2.06	2.02	2.05	2.02	2.10	2.10	2.01	1.99	2.05
Median	2.13	2.14	2.23	2.29	2.14	2.15	2.09	2.14	2.10	2.20	2.26	2.08	2.05	2.15
Max Hr. Mean	2.28	2.25	2.54	2.49	2.35	2.34	2.30	2.35	2.27	2.51	2.44	2.38	2.32	2.33
Min Hr. Mean	1.50	1.42	1.46	1.42	1.55	1.50	1.50	1.46	1.46	1.43	1.46	1.44	1.43	1.49
Inst. Max	2.33	2.35	2.57	2.56	2.57	2.46	2.56	2.43	2.30	2.62	2.50	2.64	2.40	2.58
Inst. Min	1.44	1.41	1.44	1.38	1.51	1.47	1.47	1.44	1.40	1.41	1.43	1.42	1.39	1.46

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW160002

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.87	3.62	3.80	3.93	3.79	3.78	3.88	3.99	3.79	3.87	4.01	3.90	3.93	3.88
1:00	3.21	3.06	3.18	3.49	3.21	3.18	3.26	3.45	3.27	3.40	3.35	3.33	3.39	3.37
2:00	2.84	2.58	2.83	3.12	2.84	2.90	2.83	3.02	2.92	2.96	3.13	2.92	3.03	3.00
3:00	2.59	2.40	2.74	2.87	2.75	2.66	2.60	2.81	2.74	2.90	2.93	2.88	2.85	2.81
4:00	2.70	2.48	2.57	2.70	2.89	2.83	2.73	2.82	2.73	2.75	2.76	2.82	2.91	2.88
5:00	3.22	2.97	2.59	2.59	3.38	3.45	3.24	3.29	4.08	2.61	2.66	3.26	3.43	3.40
6:00	4.01	3.72	2.91	2.73	4.04	4.15	4.04	4.04	4.04	3.01	2.78	4.15	4.19	4.09
7:00	4.63	4.37	3.74	3.38	5.64	4.84	4.67	4.74	4.70	3.83	3.50	5.67	4.72	4.65
8:00	4.68	4.78	4.28	4.47	4.98	4.91	5.26	4.78	4.85	4.70	4.52	5.04	4.72	4.88
9:00	4.46	4.73	5.08	5.20	4.59	5.20	4.62	4.66	4.76	5.33	5.20	4.58	4.79	5.34
10:00	4.55	4.47	5.68	5.66	4.80	4.64	4.46	4.68	4.77	5.78	5.67	4.46	4.83	4.68
11:00	4.61	4.54	5.64	5.81	4.76	4.76	4.65	4.86	4.81	5.83	5.72	4.60	4.81	4.70
12:00	4.58	4.56	5.56	5.71	4.95	4.64	4.68	4.66	5.06	5.94	5.53	4.52	4.82	4.67
13:00	4.39	4.41	5.49	5.30	4.60	4.72	4.61	4.51	4.69	5.79	5.37	4.31	4.42	4.57
14:00	4.53	4.16	5.45	5.36	4.36	4.43	4.63	4.27	4.60	5.70	5.59	4.38	4.31	4.37
15:00	4.33	3.98	5.02	5.19	4.48	4.25	4.32	4.28	4.33	5.53	5.47	4.48	4.35	4.37
16:00	4.39	4.17	5.02	5.19	4.38	4.19	4.32	4.43	4.30	5.42	5.50	4.36	4.36	4.28
17:00	4.36	4.28	4.97	5.02	4.48	4.30	4.39	4.54	4.69	5.22	5.26	4.56	4.47	4.40
18:00	4.77	4.34	4.99	5.03	4.66	4.73	4.64	4.75	4.67	5.10	5.29	4.77	4.59	4.69
19:00	4.85	4.49	4.90	5.18	4.97	4.90	4.86	4.83	4.63	4.97	5.48	4.71	4.74	4.89
20:00	4.91	4.52	4.98	5.33	5.12	5.06	5.05	4.97	4.71	5.04	5.55	5.10	5.10	5.02
21:00	4.87	4.69	4.92	5.51	5.31	5.11	5.23	5.21	4.78	5.21	5.61	5.25	5.25	5.17
22:00	4.81	4.38	4.78	5.31	5.13	5.04	5.35	5.17	4.68	4.79	5.19	5.21	5.18	5.06
23:00	4.30	4.26	4.49	4.57	4.56	4.53	4.75	4.56	4.42	4.41	4.80	4.58	4.70	4.68
Average	4.19	4.00	4.40	4.53	4.36	4.30	4.29	4.30	4.29	4.59	4.62	4.33	4.33	4.33
Median	4.47	4.30	4.88	5.10	4.58	4.57	4.53	4.57	4.63	5.01	5.22	4.47	4.50	4.55
Max Hr. Mean	4.91	4.78	5.68	5.81	5.64	5.20	5.35	5.21	5.06	5.94	5.72	5.67	5.25	5.34
Min Hr. Mean	2.59	2.40	2.57	2.59	2.75	2.66	2.60	2.81	2.73	2.61	2.66	2.82	2.85	2.81
Inst. Max	5.08	5.04	5.84	5.94	6.78	5.84	5.93	5.27	5.12	6.07	5.89	6.87	5.44	6.29
Inst. Min	2.49	2.38	2.51	2.56	2.67	2.61	2.55	2.75	2.65	2.53	2.63	2.79	2.82	2.77

All Values in Inches

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FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 10
Address: Litchfield Line - South
MH ID# SSMH3N1WNW220005

Date: 6/10/2008
GPS: 33.352573N -112.213261W

Overview

Street Level

Meter Details

Meter Type 2150
Serial # 206F03429
Sensor Serial # 207M02371
Telemetry None
Sample Rate 5 min

Pipe Details and Manhole Condition

Pipe Size (in) Vert. 48" Horiz. 48"
Laterals 0
Pipe Material PVC
Surcharge Evidence No
Height Above Crown (in) 0
Infiltration No
Silt No
Debris No
Grease No
Pests No

Down Manhole

Hydraulics:
Heavy pump station influence

Comments:
Very slow flow during removal

Photos
MH #SSMH3N1WNW220005
Site #10

Site ID

Down Manhole

48” Influent

48” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

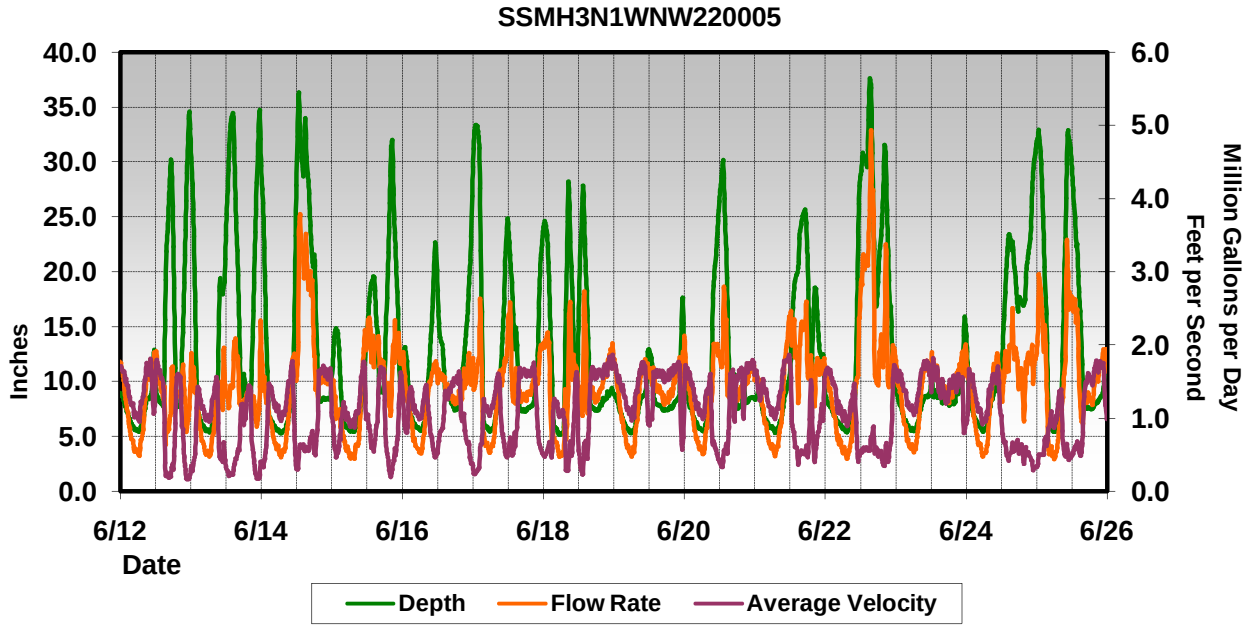
Site	**SSMH3N1WNW220005**	
Address	**Litchfield Line - South**	
Diameter	**48**	Inches
GPS	**33.352573N**	**-112.213261W**

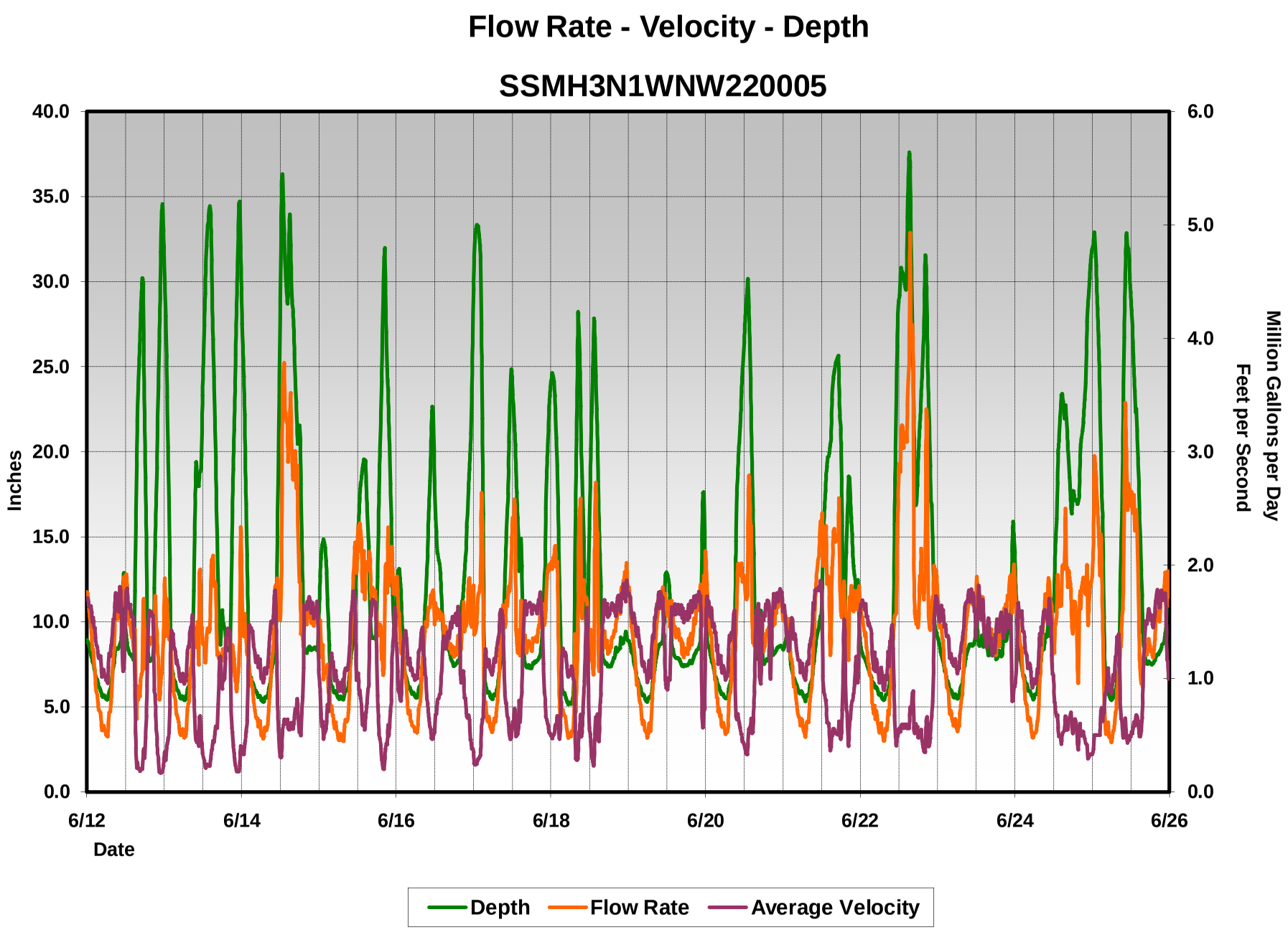
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	12.90
Maximum	37.59
Minimum	5.14
Max d/D	78.3%

Flow velocity	
	Feet per Second
Average	1.07
Maximum	1.86
Minimum	0.17

Flow Rate	
	Million Gallons per Day
Average	1.43
Maximum	4.93
Minimum	0.44
Peak Factor	3.45



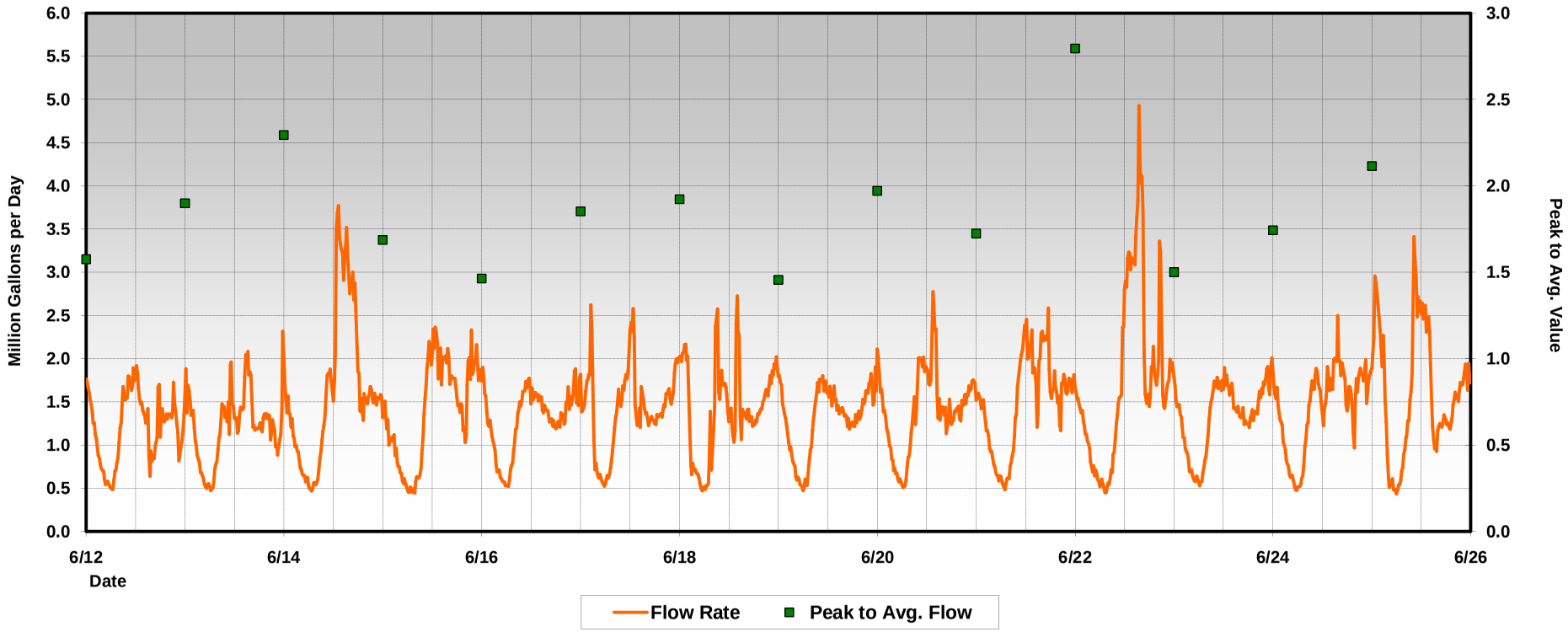

Flow Rate - Velocity - Depth
SSMH3N1WNW220005
Inches
40.0
35.0
30.0
25.0
20.0
15.0
10.0
5.0
0.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Million Gallons per Day
Feet per Second
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Depth
Flow Rate
Average Velocity

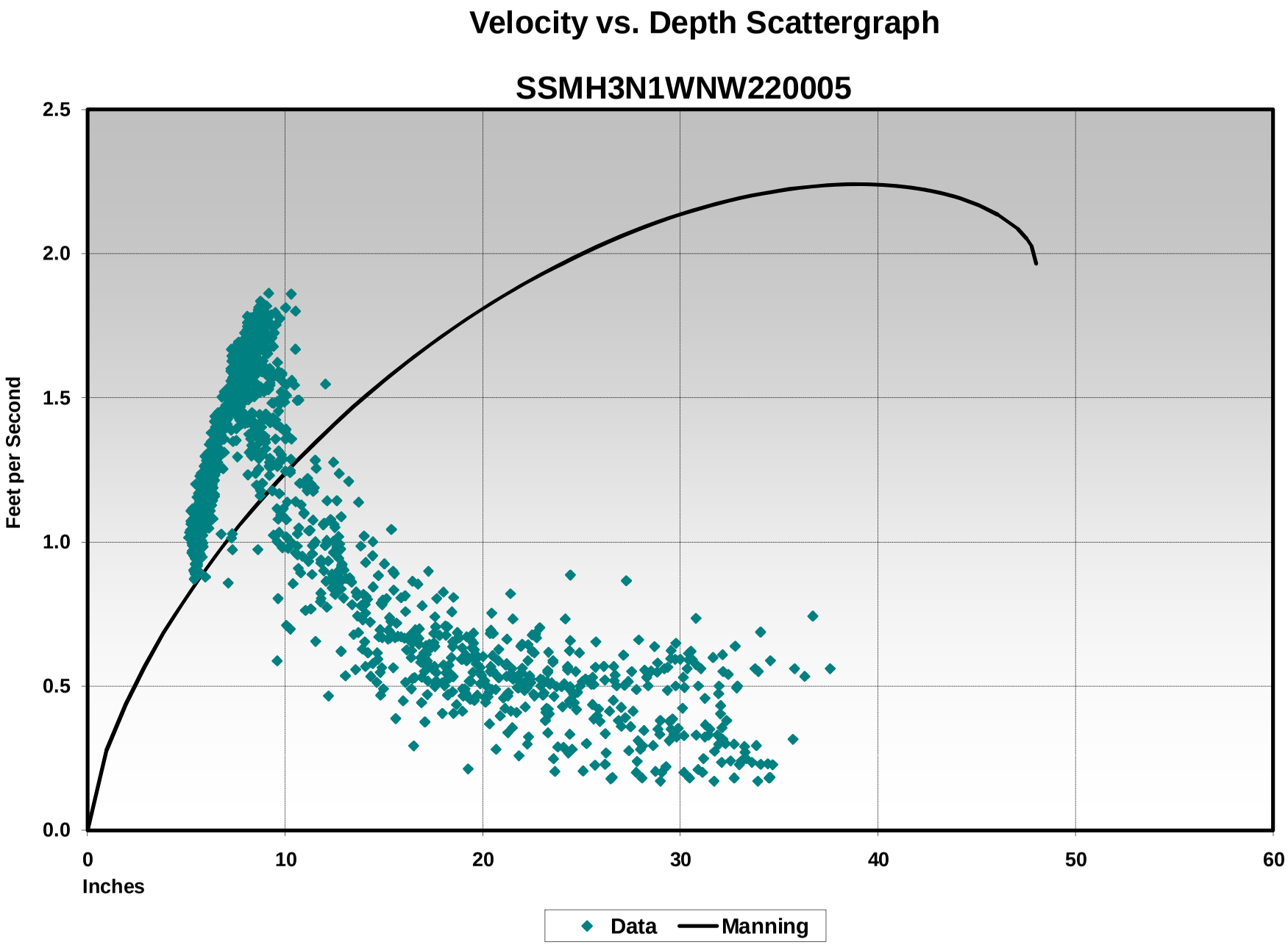
Peak to Average Flow Rate

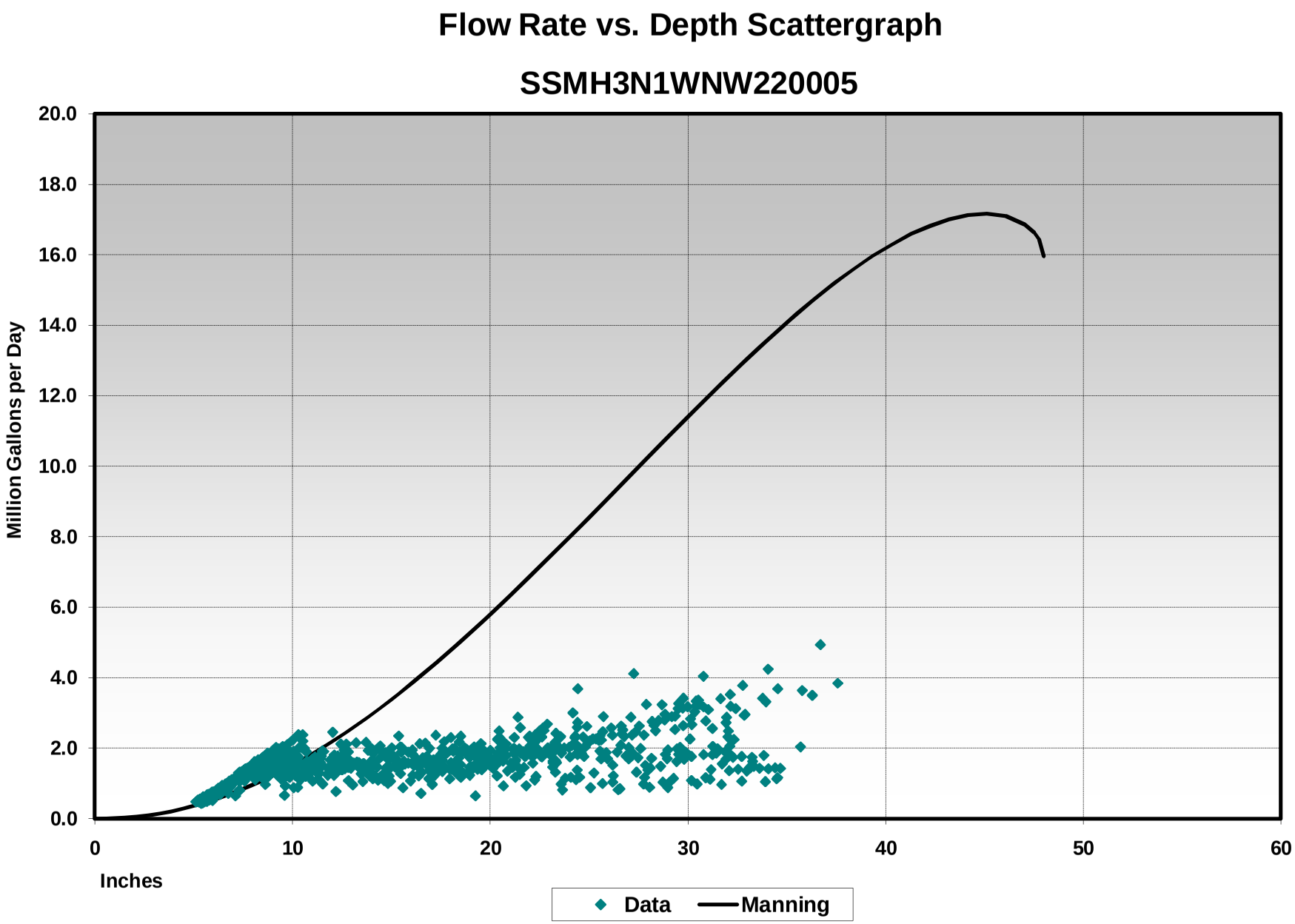
Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.58	1.90	2.29	1.69	1.46	1.85	1.92	1.46	1.97	1.72	2.80	1.50	1.74	2.12




Velocity vs. Depth Scattergraph
SSMH3N1WNW220005
Feet per Second
2.5
2.0
1.5
1.0
0.5
0.0
0
10
20
30
40
50
60
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WNW220005
Million Gallons per Day
20.0
18.0
16.0
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
10
20
30
40
50
60
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.70	1.63	1.66	1.39	1.76	1.51	2.02	1.76	1.89	1.56	1.59	1.61	1.66	2.29
1:00	1.41	1.47	1.38	1.14	1.36	1.65	2.10	1.39	1.50	1.48	1.42	1.40	1.45	2.69
2:00	1.10	1.16	1.12	1.08	1.16	2.14	1.39	1.08	1.19	1.24	1.19	1.09	1.13	2.16
3:00	0.81	0.80	0.92	0.85	0.85	1.04	0.72	0.87	0.91	0.98	0.96	0.84	0.83	1.41
4:00	0.64	0.62	0.69	0.68	0.67	0.65	0.66	0.66	0.70	0.77	0.71	0.66	0.65	0.57
5:00	0.55	0.53	0.61	0.56	0.57	0.56	0.51	0.55	0.59	0.63	0.64	0.60	0.52	0.51
6:00	0.52	0.50	0.50	0.47	0.54	0.60	0.52	0.53	0.53	0.57	0.56	0.56	0.53	0.50
7:00	0.76	0.72	0.54	0.47	0.80	0.78	0.87	0.74	0.77	0.57	0.48	0.78	0.75	0.73
8:00	1.24	1.11	0.68	0.61	1.19	1.24	1.47	1.20	1.20	0.76	0.61	1.21	1.25	1.11
9:00	1.58	1.42	1.10	0.83	1.47	1.52	2.05	1.61	1.47	1.17	0.89	1.61	1.63	1.57
10:00	1.71	1.32	1.64	1.62	1.65	1.65	1.74	1.77	2.00	1.83	1.41	1.70	1.80	2.99
11:00	1.74	1.70	1.76	2.07	1.71	1.87	1.59	1.67	1.92	2.19	1.97	1.71	1.62	2.61
12:00	1.80	1.27	2.20	2.22	1.56	2.41	1.33	1.61	1.79	2.21	2.92	1.76	1.38	2.55
13:00	1.48	1.35	3.54	2.01	1.57	1.57	1.43	1.56	2.35	2.12	3.16	1.66	1.73	2.45
14:00	1.31	1.67	3.15	1.96	1.52	1.39	2.16	1.44	1.90	1.68	3.19	1.54	1.79	1.75
15:00	0.97	1.92	3.25	2.02	1.41	1.47	1.30	1.41	1.42	1.90	4.16	1.40	2.11	0.98
16:00	0.88	1.44	2.88	1.82	1.32	1.30	1.37	1.31	1.33	2.26	3.47	1.36	1.93	1.22
17:00	1.37	1.19	2.54	1.75	1.25	1.30	1.28	1.25	1.35	2.23	1.55	1.26	1.74	1.28
18:00	1.30	1.20	1.65	1.47	1.23	1.29	1.26	1.26	1.30	1.61	1.70	1.28	1.56	1.25
19:00	1.31	1.34	1.45	1.33	1.32	1.35	1.38	1.33	1.42	1.66	1.86	1.36	1.28	1.31
20:00	1.35	1.26	1.53	1.45	1.37	1.48	1.51	1.44	1.39	1.42	2.60	1.47	1.67	1.56
21:00	1.50	1.20	1.58	1.98	1.53	1.60	1.64	1.59	1.53	1.72	1.70	1.63	1.84	1.64
22:00	1.02	0.96	1.54	1.99	1.72	1.62	1.80	1.74	1.63	1.69	1.66	1.82	1.77	1.81
23:00	1.13	1.48	1.55	1.84	1.57	1.97	1.93	1.63	1.74	1.71	1.93	1.78	1.76	1.80
Average	1.22	1.22	1.64	1.40	1.30	1.42	1.42	1.31	1.41	1.50	1.76	1.34	1.43	1.61
Median	1.29	1.24	1.53	1.48	1.38	1.42	1.41	1.39	1.43	1.60	1.55	1.41	1.59	1.53
Max Hr. Mean	1.80	1.92	3.54	2.22	1.76	2.41	2.16	1.77	2.35	2.26	4.16	1.82	2.11	2.99
Min Hr. Mean	0.52	0.50	0.50	0.47	0.54	0.56	0.51	0.53	0.53	0.57	0.48	0.56	0.52	0.50
Inst. Max	1.92	2.32	3.77	2.37	1.90	2.62	2.73	1.91	2.78	2.59	4.93	2.01	2.50	3.41
Inst. Min	0.49	0.48	0.47	0.45	0.52	0.53	0.47	0.48	0.51	0.48	0.45	0.53	0.48	0.44

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.68	0.32	0.35	0.90	1.14	0.27	0.49	1.73	1.54	1.60	1.64	1.57	1.07	0.39
1:00	1.59	0.54	0.51	0.54	0.85	0.28	0.56	1.55	1.62	1.36	1.64	1.60	1.60	0.50
2:00	1.45	1.34	1.27	0.62	1.30	0.46	0.57	1.44	1.50	1.40	1.51	1.46	1.50	0.55
3:00	1.24	1.23	1.39	0.97	1.28	0.95	1.00	1.35	1.34	1.41	1.38	1.32	1.26	0.69
4:00	1.12	1.10	1.19	1.13	1.13	1.14	1.22	1.17	1.17	1.24	1.13	1.17	1.11	0.93
5:00	1.04	1.01	1.14	1.01	1.03	1.07	1.06	1.08	1.08	1.12	1.10	1.12	0.98	0.96
6:00	1.00	0.98	1.00	0.91	1.03	1.12	1.07	1.04	1.01	1.06	1.03	1.08	0.97	0.96
7:00	1.25	1.21	1.05	0.92	1.29	1.29	0.78	1.24	1.27	1.08	0.94	1.27	1.18	1.20
8:00	1.52	1.46	1.19	1.07	1.32	1.55	0.34	1.51	1.44	1.27	1.09	1.54	1.41	1.18
9:00	1.65	0.87	1.48	1.21	0.92	1.26	0.57	1.67	0.97	1.55	1.29	1.71	1.58	0.56
10:00	1.69	0.46	1.65	1.66	0.62	0.72	0.94	1.73	0.62	1.78	1.08	1.70	1.57	0.55
11:00	1.16	0.56	0.75	1.40	0.49	0.50	1.35	1.18	0.47	1.81	0.48	1.67	1.33	0.46
12:00	1.70	0.28	0.36	0.95	0.67	0.63	0.46	0.95	0.37	1.31	0.55	1.55	0.82	0.52
13:00	1.62	0.23	0.61	0.69	0.84	0.55	0.31	1.37	0.47	0.77	0.58	1.62	0.60	0.63
14:00	1.47	0.28	0.59	0.65	1.19	0.70	0.61	1.60	0.56	0.53	0.58	1.52	0.47	0.58
15:00	0.45	0.45	0.58	0.98	1.28	1.22	0.79	1.63	1.14	0.49	0.64	1.40	0.57	0.62
16:00	0.20	0.62	0.64	1.61	1.40	1.63	1.59	1.59	1.47	0.53	0.76	1.38	0.58	1.35
17:00	0.28	1.10	0.73	1.65	1.50	1.65	1.59	1.56	1.20	0.54	0.56	1.24	0.66	1.56
18:00	0.59	0.98	0.57	0.82	1.53	1.61	1.59	1.57	1.57	0.68	0.50	1.44	0.58	1.53
19:00	1.51	1.34	1.30	0.36	1.55	1.61	1.63	1.60	1.65	1.16	0.44	1.50	0.49	1.55
20:00	1.50	1.23	1.64	0.27	1.02	1.69	1.62	1.65	1.24	0.54	0.50	1.45	0.55	1.73
21:00	0.70	0.46	1.65	0.48	0.86	1.42	1.66	1.70	1.68	0.75	0.45	1.53	0.51	1.71
22:00	0.25	0.21	1.60	0.81	0.66	0.75	1.75	1.60	1.70	1.02	0.78	1.51	0.39	1.73
23:00	0.19	0.25	1.62	1.47	0.42	0.55	1.79	0.68	1.77	1.21	1.63	0.90	0.32	1.22
Average	1.12	0.77	1.04	0.96	1.05	1.03	1.06	1.42	1.20	1.09	0.93	1.43	0.92	0.99
Median	1.28	0.71	1.08	0.96	1.07	1.07	1.05	1.54	1.29	1.13	0.89	1.47	0.92	0.89
Max Hr. Mean	1.70	1.46	1.65	1.66	1.55	1.69	1.79	1.73	1.77	1.81	1.64	1.71	1.60	1.73
Min Hr. Mean	0.19	0.21	0.35	0.27	0.42	0.27	0.31	0.68	0.37	0.49	0.44	0.90	0.32	0.39
Inst. Max	1.81	1.56	1.77	1.77	1.63	1.76	1.86	1.77	1.79	1.86	1.73	1.81	1.70	1.78
Inst. Min	0.17	0.18	0.30	0.20	0.38	0.24	0.23	0.57	0.33	0.37	0.35	0.80	0.29	0.33

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNW220005

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	8.75	28.82	26.94	11.96	11.85	31.60	24.37	8.76	10.18	8.51	8.47	8.82	12.03	32.32
1:00	7.97	18.60	18.15	14.65	12.07	33.16	22.64	8.05	8.21	9.19	7.84	7.93	8.08	30.26
2:00	7.18	7.96	8.20	13.02	8.10	28.23	15.82	7.09	7.40	8.03	7.33	7.08	7.13	23.77
3:00	6.45	6.44	6.48	8.12	6.54	9.95	7.26	6.36	6.62	6.74	6.71	6.33	6.47	14.38
4:00	5.87	5.87	5.97	6.07	6.03	5.90	5.69	5.80	6.07	6.22	6.29	5.87	5.98	6.18
5:00	5.60	5.55	5.62	5.81	5.76	5.59	5.23	5.45	5.70	5.84	5.97	5.64	5.61	5.63
6:00	5.50	5.44	5.37	5.52	5.58	5.64	5.25	5.48	5.51	5.64	5.68	5.53	5.67	5.54
7:00	6.16	6.03	5.47	5.48	6.23	6.14	10.51	6.06	6.13	5.56	5.44	6.18	6.30	6.12
8:00	7.51	7.15	5.89	5.90	8.17	7.44	25.13	7.40	7.62	6.09	5.80	7.31	8.06	8.65
9:00	8.42	13.56	7.02	6.67	12.23	10.19	21.85	8.43	12.88	7.14	6.66	8.30	8.87	18.37
10:00	8.75	18.59	8.63	8.50	17.58	15.67	13.80	8.80	20.07	8.82	11.21	8.65	9.49	30.45
11:00	11.57	19.43	17.47	11.79	21.54	22.69	10.09	11.33	24.04	9.91	24.13	8.83	10.15	31.37
12:00	9.07	26.32	33.04	15.89	15.99	22.95	18.98	12.55	27.70	13.03	29.75	9.66	12.67	27.80
13:00	8.15	32.45	32.36	18.65	13.45	18.27	26.26	9.72	28.75	18.02	30.36	8.83	18.69	23.32
14:00	8.03	33.41	29.95	19.18	10.41	14.19	21.43	8.06	20.58	19.94	31.03	8.77	22.78	18.85
15:00	17.14	25.50	31.35	14.83	9.31	10.29	12.98	7.85	10.67	23.00	36.04	8.83	22.50	12.31
16:00	25.78	15.98	26.32	9.46	8.35	7.42	7.87	7.57	8.23	25.08	26.13	8.58	20.75	8.11
17:00	28.76	9.25	21.40	9.03	7.66	7.36	7.48	7.43	9.60	24.42	17.86	8.86	17.31	7.58
18:00	16.72	10.06	18.85	13.95	7.47	7.43	7.39	7.46	7.60	16.98	20.80	7.99	17.47	7.54
19:00	7.91	8.71	9.75	22.95	7.76	7.67	7.74	7.61	7.83	11.57	25.14	8.11	17.05	7.71
20:00	8.10	9.09	8.27	30.33	10.72	7.91	8.27	7.90	9.55	17.51	29.71	8.81	19.52	8.07
21:00	15.58	17.70	8.43	24.39	13.14	9.55	8.57	8.30	8.13	15.67	22.39	9.09	22.06	8.42
22:00	25.20	26.96	8.43	17.09	17.21	15.30	8.83	9.42	8.45	12.45	15.37	9.86	26.55	8.94
23:00	33.30	33.49	8.42	10.18	22.81	21.74	9.15	16.32	8.56	11.21	9.78	14.25	30.47	11.59
Average	12.23	16.35	14.91	12.89	11.08	13.84	13.02	8.30	11.50	12.36	16.50	8.26	14.24	15.14
Median	8.43	13.88	8.51	11.35	9.64	9.56	9.13	7.85	8.27	10.03	13.75	8.44	12.26	9.75
Max Hr. Mean	33.30	33.49	33.04	30.33	22.81	33.16	26.26	16.32	28.75	25.08	36.04	14.25	30.47	32.32
Min Hr. Mean	5.50	5.44	5.37	5.48	5.58	5.59	5.23	5.45	5.51	5.56	5.44	5.53	5.61	5.54
Inst. Max	34.55	34.69	36.31	31.95	26.88	33.35	28.11	17.62	30.12	25.63	37.59	15.87	31.44	32.91
Inst. Min	5.42	5.39	5.29	5.41	5.53	5.46	5.14	5.31	5.51	5.31	5.39	5.47	5.42	5.40

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 11**	**Date:**	**6/9/2008**
Address:	**N Reems Road S of W Sunnyside Drive**	**GPS:**	**33.352888N -112.233777W**
MH ID#	**SSMH3N1WNE190089**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**204M00191**
Sensor Serial #	**204K01284**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**26"**	**Horiz.**	**26"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole

Hydraulics:
Moderate flow conditions. Fairly clear water.

Comments:
Pipe diameter measured at 26". Not 30" diameter as specified.

Photos
MH #SSMH3N1WNE190089
Site #11

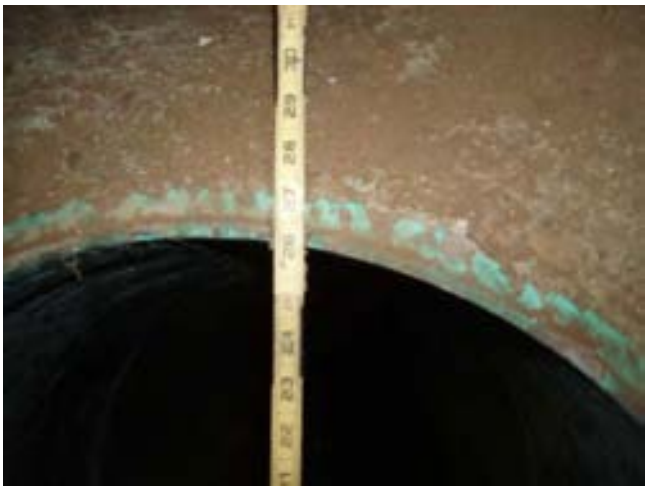
Site ID

Down Manhole

26” Influent

26” Effluent

Manhole Cover Top


Measured 26”

Location Summary

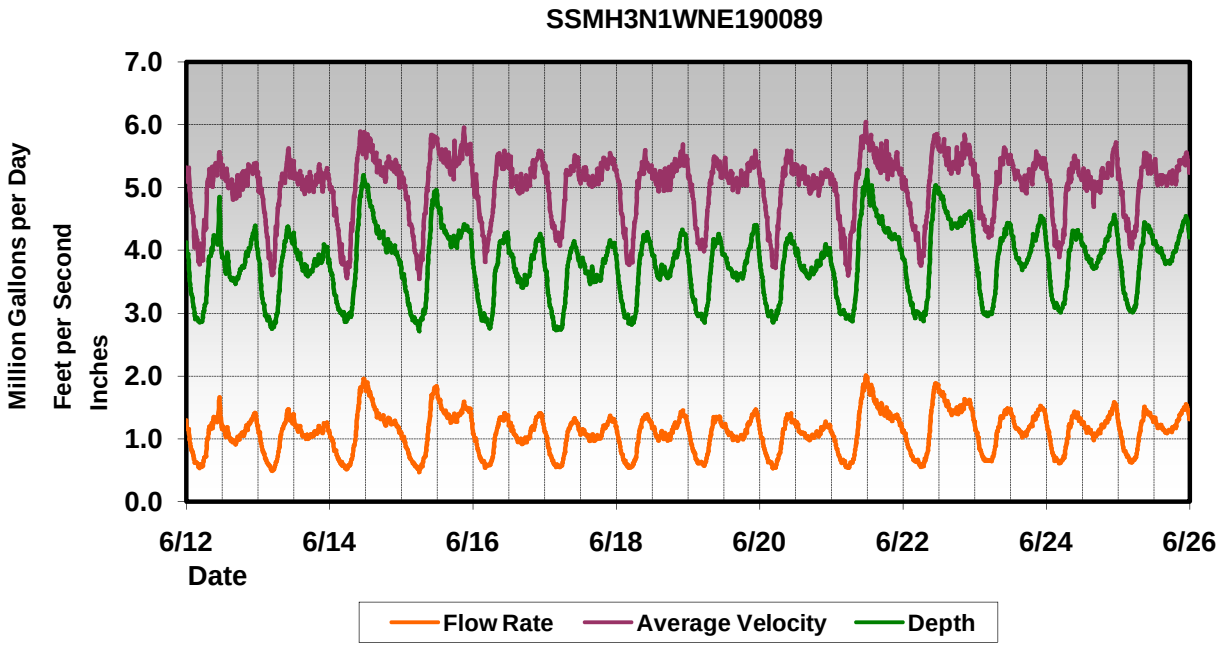
Site	**SSMH3N1WNE190089**
Address	**Reems Rd S of Sunnyside Drive**
Diameter	**26** Inches
GPS	**33.352888N -112.233777W**

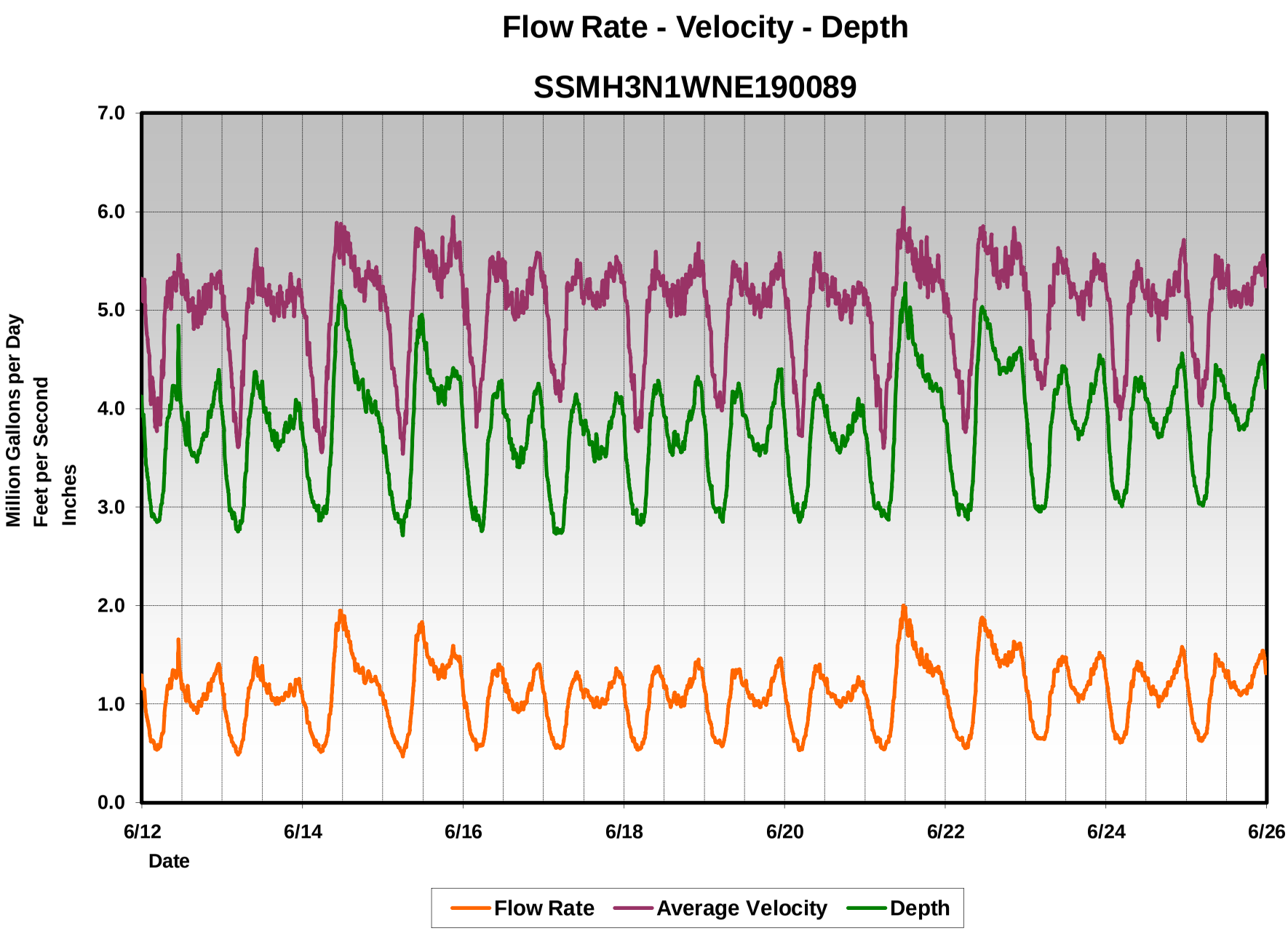
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	3.79
Maximum	5.27
Minimum	2.72
Max d/D	20.3%

Flow velocity	
	Feet per Second
Average	5.03
Maximum	6.04
Minimum	3.54

Flow Rate	
	Million Gallons per Day
Average	1.11
Maximum	2.00
Minimum	0.47
Peak Factor	1.81



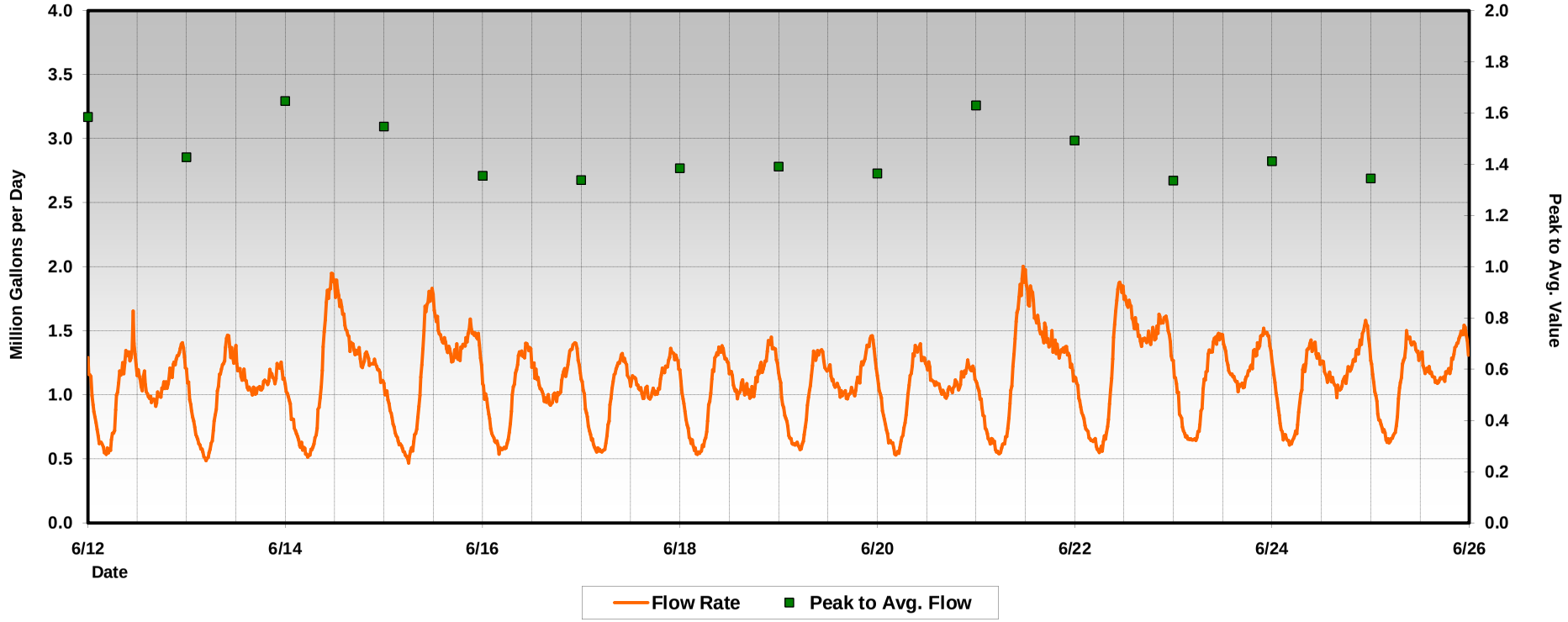

Flow Rate - Velocity - Depth
SSMH3N1WNE190089
Million Gallons per Day
Feet per Second
Inches
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

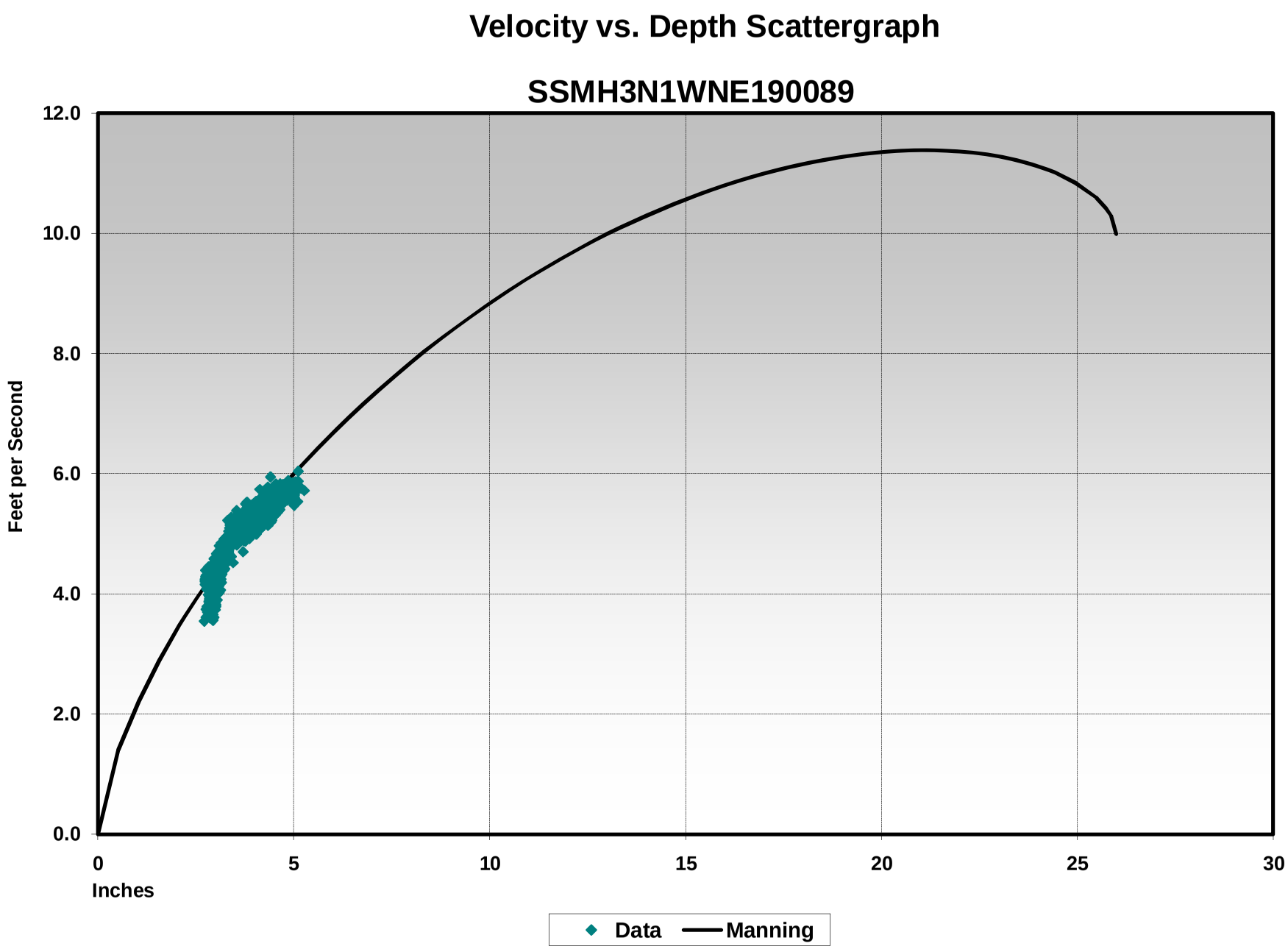
Peak to Average Flow Rate

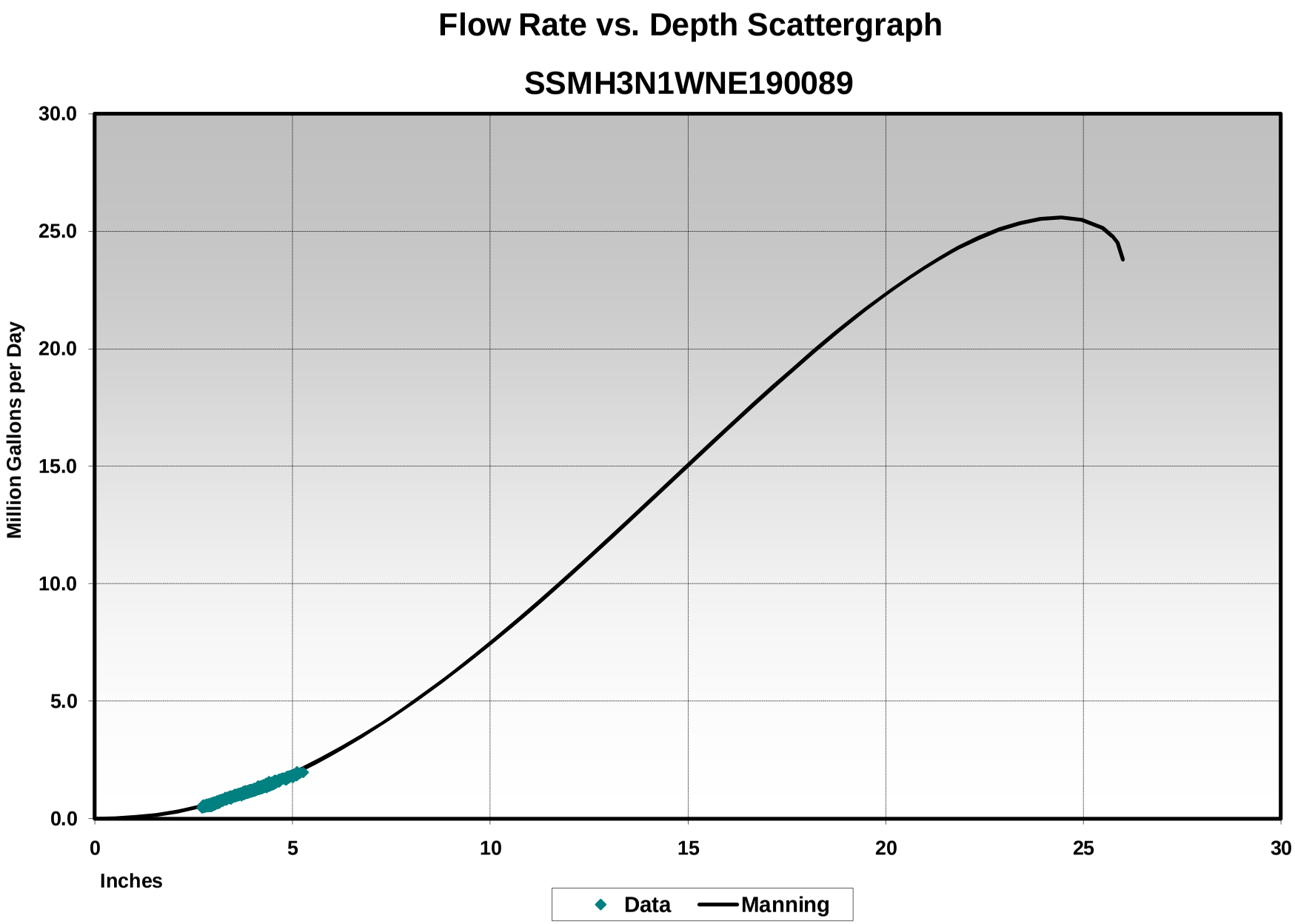
Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.58	1.43	1.65	1.55	1.36	1.34	1.39	1.39	1.36	1.63	1.49	1.34	1.41	1.35




Velocity vs. Depth Scattergraph
SSMH3N1WNE190089
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N1WNE190089
Million Gallons per Day
30.0
25.0
20.0
15.0
10.0
5.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.19	1.09	1.03	1.03	1.03	1.07	1.07	1.09	1.07	1.07	1.11	1.16	1.18	1.19
1:00	0.90	0.86	0.88	0.91	0.88	0.83	0.84	0.87	0.88	0.92	0.92	0.93	0.93	0.95
2:00	0.70	0.69	0.74	0.76	0.69	0.68	0.67	0.72	0.70	0.75	0.79	0.75	0.72	0.78
3:00	0.62	0.60	0.63	0.65	0.63	0.58	0.60	0.63	0.63	0.65	0.69	0.67	0.67	0.70
4:00	0.56	0.52	0.59	0.59	0.57	0.57	0.54	0.62	0.55	0.62	0.64	0.65	0.62	0.64
5:00	0.59	0.53	0.53	0.53	0.58	0.57	0.58	0.59	0.58	0.55	0.60	0.65	0.68	0.68
6:00	0.75	0.70	0.57	0.53	0.69	0.72	0.70	0.72	0.72	0.59	0.57	0.77	0.82	0.82
7:00	1.07	0.96	0.68	0.65	1.00	1.01	1.00	1.00	0.96	0.68	0.67	1.05	1.12	1.13
8:00	1.19	1.19	0.96	0.87	1.23	1.19	1.24	1.26	1.22	0.96	0.88	1.26	1.28	1.36
9:00	1.31	1.33	1.41	1.31	1.32	1.27	1.34	1.31	1.34	1.39	1.35	1.36	1.38	1.43
10:00	1.31	1.40	1.78	1.69	1.35	1.28	1.35	1.34	1.35	1.73	1.77	1.44	1.37	1.40
11:00	1.40	1.31	1.90	1.79	1.36	1.16	1.27	1.22	1.27	1.89	1.85	1.46	1.28	1.32
12:00	1.15	1.25	1.84	1.66	1.21	1.12	1.17	1.20	1.23	1.84	1.74	1.39	1.24	1.30
13:00	1.11	1.16	1.72	1.52	1.13	1.10	1.05	1.09	1.11	1.79	1.70	1.22	1.14	1.20
14:00	1.03	1.12	1.58	1.42	1.03	1.04	1.01	1.07	1.09	1.62	1.57	1.15	1.13	1.19
15:00	0.97	1.04	1.44	1.37	0.96	1.00	1.07	1.00	1.04	1.54	1.50	1.09	1.05	1.13
16:00	0.94	1.03	1.39	1.30	0.95	1.00	1.05	1.00	1.00	1.48	1.41	1.08	1.05	1.10
17:00	1.00	1.05	1.33	1.33	0.98	1.02	1.02	1.02	1.04	1.44	1.43	1.09	1.11	1.13
18:00	1.06	1.06	1.27	1.31	1.00	1.02	1.07	1.02	1.05	1.40	1.45	1.19	1.17	1.16
19:00	1.09	1.10	1.29	1.38	1.12	1.13	1.21	1.11	1.08	1.39	1.47	1.28	1.22	1.22
20:00	1.19	1.16	1.27	1.46	1.19	1.20	1.22	1.24	1.12	1.33	1.56	1.35	1.31	1.34
21:00	1.27	1.12	1.25	1.52	1.34	1.29	1.36	1.35	1.18	1.35	1.58	1.44	1.38	1.43
22:00	1.35	1.22	1.21	1.46	1.40	1.32	1.39	1.43	1.23	1.33	1.57	1.49	1.52	1.50
23:00	1.32	1.17	1.12	1.35	1.26	1.26	1.31	1.32	1.18	1.19	1.37	1.41	1.48	1.43
Average	1.04	1.03	1.18	1.18	1.04	1.02	1.05	1.05	1.03	1.23	1.26	1.14	1.12	1.15
Median	1.08	1.10	1.24	1.33	1.05	1.06	1.08	1.07	1.08	1.33	1.43	1.17	1.16	1.18
Max Hr. Mean	1.40	1.40	1.90	1.79	1.40	1.32	1.39	1.43	1.35	1.89	1.85	1.49	1.52	1.50
Min Hr. Mean	0.56	0.52	0.53	0.53	0.57	0.57	0.54	0.59	0.55	0.55	0.57	0.65	0.62	0.64
Inst. Max	1.66	1.47	1.95	1.83	1.41	1.36	1.45	1.46	1.40	2.00	1.88	1.52	1.58	1.54
Inst. Min	0.54	0.49	0.51	0.47	0.54	0.55	0.54	0.57	0.53	0.54	0.55	0.64	0.61	0.63

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.21	5.06	4.99	5.15	5.05	5.22	5.16	5.15	5.12	5.15	5.09	5.18	5.15	5.16
1:00	4.84	4.90	4.77	4.93	4.97	4.88	4.79	4.91	4.89	4.97	4.89	4.84	4.97	4.83
2:00	4.37	4.50	4.47	4.64	4.50	4.45	4.31	4.48	4.47	4.60	4.64	4.57	4.37	4.50
3:00	4.21	4.07	4.05	4.35	4.23	4.28	4.02	4.17	4.17	4.24	4.37	4.38	4.14	4.35
4:00	3.90	3.75	3.89	4.06	3.95	4.22	3.84	4.11	3.81	4.07	4.23	4.31	4.00	4.10
5:00	3.98	3.83	3.65	3.77	4.25	4.19	4.04	4.05	3.87	3.70	3.95	4.29	4.18	4.28
6:00	4.52	4.51	3.76	3.76	4.56	4.63	4.58	4.49	4.51	4.07	3.87	4.61	4.65	4.57
7:00	5.12	4.93	4.35	4.25	5.07	5.23	5.08	5.04	5.04	4.43	4.32	5.07	5.13	5.10
8:00	5.16	5.19	4.96	4.83	5.50	5.26	5.30	5.35	5.29	5.10	4.82	5.29	5.21	5.39
9:00	5.28	5.27	5.47	5.41	5.41	5.30	5.38	5.39	5.49	5.35	5.36	5.47	5.42	5.44
10:00	5.31	5.43	5.73	5.75	5.44	5.42	5.35	5.37	5.40	5.74	5.77	5.53	5.34	5.35
11:00	5.43	5.31	5.72	5.76	5.42	5.26	5.30	5.20	5.31	5.84	5.77	5.43	5.17	5.27
12:00	5.23	5.23	5.69	5.63	5.29	5.16	5.23	5.31	5.33	5.71	5.60	5.42	5.18	5.35
13:00	5.18	5.11	5.73	5.53	5.14	5.25	5.11	5.15	5.16	5.72	5.65	5.21	5.07	5.12
14:00	5.04	5.13	5.54	5.48	5.09	5.13	5.11	5.20	5.21	5.51	5.49	5.20	5.17	5.14
15:00	4.98	5.02	5.43	5.44	4.95	5.08	5.12	5.04	5.13	5.46	5.42	5.09	4.96	5.13
16:00	4.93	5.06	5.37	5.31	5.06	5.11	5.13	5.03	5.06	5.44	5.31	5.09	4.99	5.09
17:00	5.04	5.13	5.22	5.38	5.08	5.21	5.11	5.09	5.01	5.40	5.35	5.03	5.03	5.19
18:00	5.09	5.04	5.22	5.38	5.06	5.22	5.15	5.10	5.12	5.42	5.42	5.23	5.14	5.14
19:00	5.13	5.09	5.39	5.45	5.20	5.32	5.35	5.14	5.04	5.41	5.42	5.22	5.18	5.18
20:00	5.21	5.27	5.36	5.65	5.28	5.40	5.34	5.33	5.08	5.31	5.69	5.39	5.27	5.35
21:00	5.30	5.07	5.30	5.74	5.46	5.40	5.45	5.41	5.18	5.39	5.62	5.44	5.26	5.42
22:00	5.30	5.20	5.34	5.59	5.56	5.46	5.44	5.45	5.23	5.35	5.56	5.41	5.56	5.46
23:00	5.30	5.20	5.17	5.46	5.38	5.34	5.45	5.34	5.17	5.16	5.35	5.37	5.58	5.41
Average	4.96	4.93	5.02	5.11	5.04	5.06	5.01	5.01	4.96	5.11	5.12	5.09	5.01	5.05
Median	5.11	5.08	5.28	5.36	5.14	5.20	5.19	5.15	5.12	5.29	5.36	5.19	5.12	5.17
Max Hr. Mean	5.43	5.43	5.73	5.76	5.56	5.46	5.45	5.45	5.49	5.84	5.77	5.53	5.58	5.46
Min Hr. Mean	3.90	3.75	3.65	3.76	3.95	4.19	3.84	4.05	3.81	3.70	3.87	4.29	4.00	4.10
Inst. Max	5.56	5.61	5.89	5.95	5.58	5.54	5.68	5.58	5.58	6.04	5.85	5.63	5.71	5.55
Inst. Min	3.78	3.61	3.56	3.54	3.82	4.08	3.77	3.98	3.72	3.60	3.76	4.20	3.90	4.03

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WNE190089

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.95	3.79	3.68	3.61	3.66	3.66	3.69	3.76	3.72	3.70	3.82	3.88	3.95	3.98
1:00	3.43	3.29	3.40	3.40	3.32	3.23	3.30	3.32	3.34	3.41	3.47	3.50	3.44	3.57
2:00	3.10	3.01	3.17	3.15	3.02	2.99	3.03	3.11	3.06	3.13	3.22	3.14	3.15	3.26
3:00	2.92	2.91	3.03	2.95	2.94	2.77	2.95	2.97	2.98	2.99	3.07	2.99	3.12	3.10
4:00	2.86	2.79	2.99	2.90	2.89	2.75	2.84	2.96	2.88	3.00	2.99	2.97	3.04	3.03
5:00	2.92	2.82	2.89	2.82	2.79	2.76	2.87	2.90	2.96	2.94	2.99	2.99	3.11	3.07
6:00	3.17	3.01	2.97	2.85	2.97	3.02	3.01	3.09	3.08	2.90	2.93	3.17	3.29	3.32
7:00	3.72	3.53	3.04	2.99	3.58	3.53	3.57	3.58	3.49	2.99	3.02	3.68	3.82	3.87
8:00	3.97	3.96	3.52	3.33	3.89	3.92	4.02	4.03	3.97	3.46	3.38	4.06	4.16	4.23
9:00	4.18	4.23	4.28	4.10	4.14	4.08	4.19	4.12	4.14	4.31	4.22	4.18	4.26	4.36
10:00	4.16	4.29	4.89	4.71	4.18	4.04	4.24	4.21	4.21	4.80	4.85	4.32	4.28	4.35
11:00	4.31	4.17	5.13	4.90	4.22	3.86	4.08	4.01	4.09	5.03	4.99	4.41	4.20	4.22
12:00	3.86	4.08	5.03	4.71	3.95	3.81	3.89	3.91	3.97	5.02	4.89	4.29	4.07	4.12
13:00	3.77	3.92	4.78	4.48	3.86	3.73	3.67	3.76	3.79	4.91	4.80	4.01	3.91	4.01
14:00	3.65	3.83	4.60	4.32	3.64	3.64	3.58	3.68	3.71	4.71	4.62	3.87	3.84	3.98
15:00	3.53	3.70	4.38	4.23	3.53	3.58	3.70	3.60	3.64	4.57	4.51	3.77	3.75	3.85
16:00	3.50	3.65	4.30	4.14	3.44	3.55	3.65	3.59	3.58	4.45	4.39	3.75	3.73	3.81
17:00	3.59	3.66	4.26	4.18	3.52	3.56	3.60	3.61	3.68	4.39	4.41	3.82	3.86	3.83
18:00	3.72	3.73	4.13	4.13	3.56	3.55	3.70	3.61	3.66	4.32	4.40	3.94	3.94	3.92
19:00	3.76	3.81	4.08	4.25	3.79	3.76	3.91	3.81	3.79	4.28	4.45	4.16	4.04	4.03
20:00	3.96	3.85	4.04	4.31	3.93	3.87	3.95	4.01	3.85	4.21	4.49	4.20	4.19	4.20
21:00	4.08	3.86	4.04	4.37	4.14	4.06	4.19	4.19	3.94	4.21	4.55	4.38	4.35	4.36
22:00	4.26	4.03	3.94	4.33	4.22	4.10	4.28	4.36	4.02	4.19	4.58	4.50	4.48	4.49
23:00	4.19	3.92	3.82	4.16	4.02	4.04	4.09	4.17	3.96	3.97	4.26	4.35	4.38	4.37
Average	3.69	3.66	3.93	3.89	3.63	3.58	3.67	3.68	3.65	4.00	4.05	3.85	3.85	3.89
Median	3.74	3.78	4.01	4.19	3.67	3.66	3.73	3.72	3.72	4.21	4.39	3.92	3.93	3.98
Max Hr. Mean	4.31	4.29	5.13	4.90	4.22	4.10	4.28	4.36	4.21	5.03	4.99	4.50	4.48	4.49
Min Hr. Mean	2.86	2.79	2.89	2.82	2.79	2.75	2.84	2.90	2.88	2.90	2.93	2.97	3.04	3.03
Inst. Max	4.84	4.37	5.19	4.95	4.28	4.16	4.32	4.40	4.25	5.27	5.03	4.54	4.56	4.54
Inst. Min	2.85	2.75	2.87	2.72	2.76	2.73	2.82	2.85	2.85	2.87	2.88	2.96	3.01	3.02

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 12
Address: N Sunrise Blvd N of Bell Road
MH ID# SSMH4N1WSW310016

Date: 6/9/2008
GPS: 33.382344N -112.241700W

Overview

Street Level

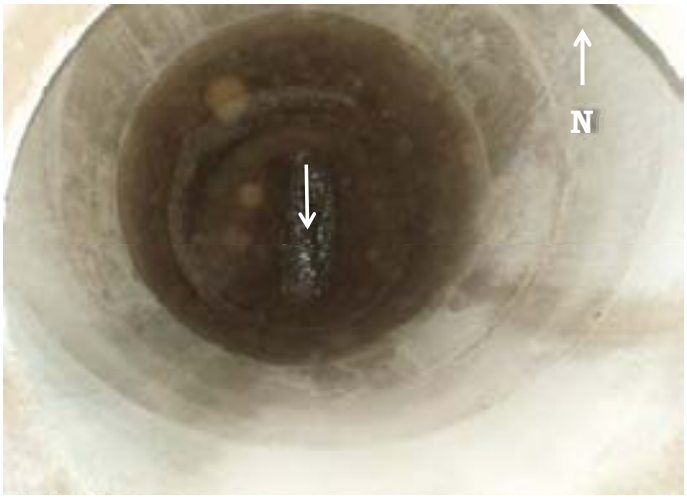
Meter Details

Meter Type	2150
Serial #	203A01267
Sensor Serial #	205E00559
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	18"	Horiz.	18"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole



Hydraulics:
Moderate flow conditions

Comments:
Good monitoring site

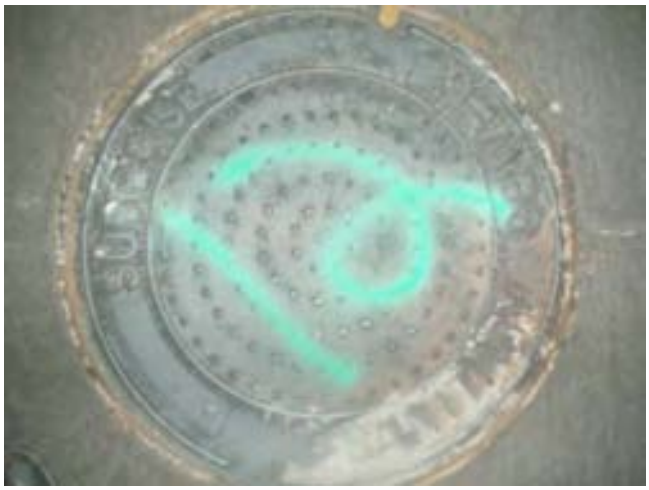
Photos
MH #SSMH4N1WSW310016
Site #12

Site ID

Down Manhole

18” Influent

18” Effluent


Manhole Cover Top

Manhole Cover Bottom

Location Summary

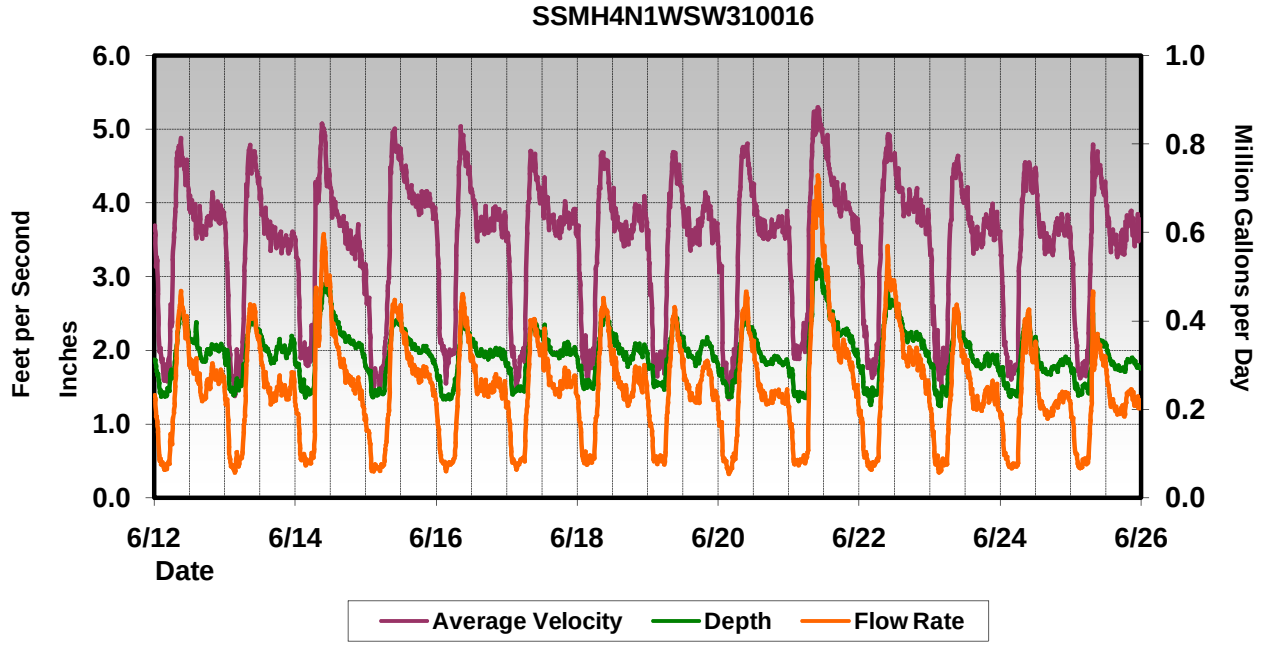
Site	**SSMH4N1WSW310016**	
Address	**Sunrise Blvd N of Bell Road**	
Diameter	**18**	Inches
GPS	**33.382344N**	**-112.241700W**

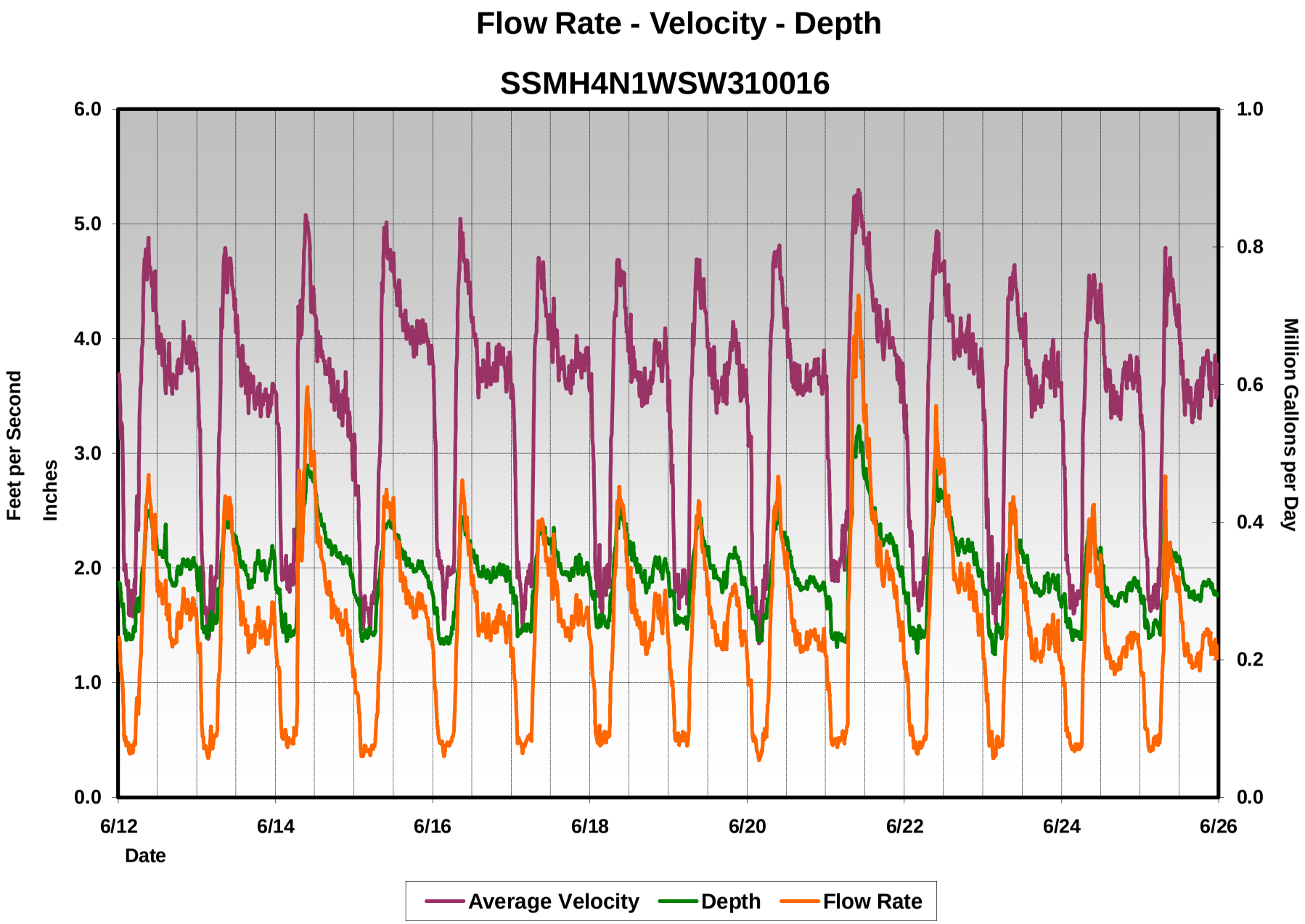
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	1.94
Maximum	3.24
Minimum	1.25
Max d/D	18.0%

Flow velocity	
	Feet per Second
Average	3.46
Maximum	5.30
Minimum	1.34

Flow Rate	
	Million Gallons per Day
Average	0.25
Maximum	0.73
Minimum	0.05
Peak Factor	2.95



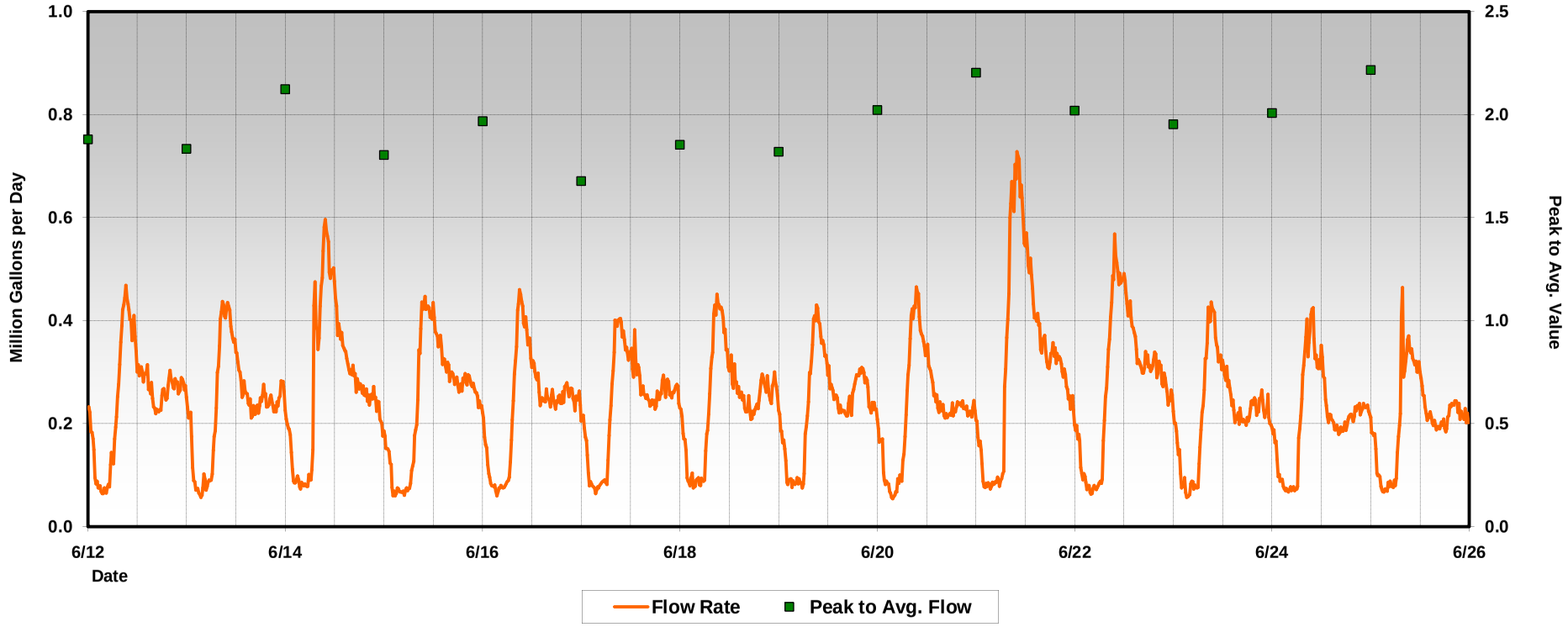

Flow Rate - Velocity - Depth
SSMH4N1WSW310016
Feet per Second
Inches
Million Gallons per Day
6.0
5.0
4.0
3.0
2.0
1.0
0.0
1.0
0.8
0.6
0.4
0.2
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

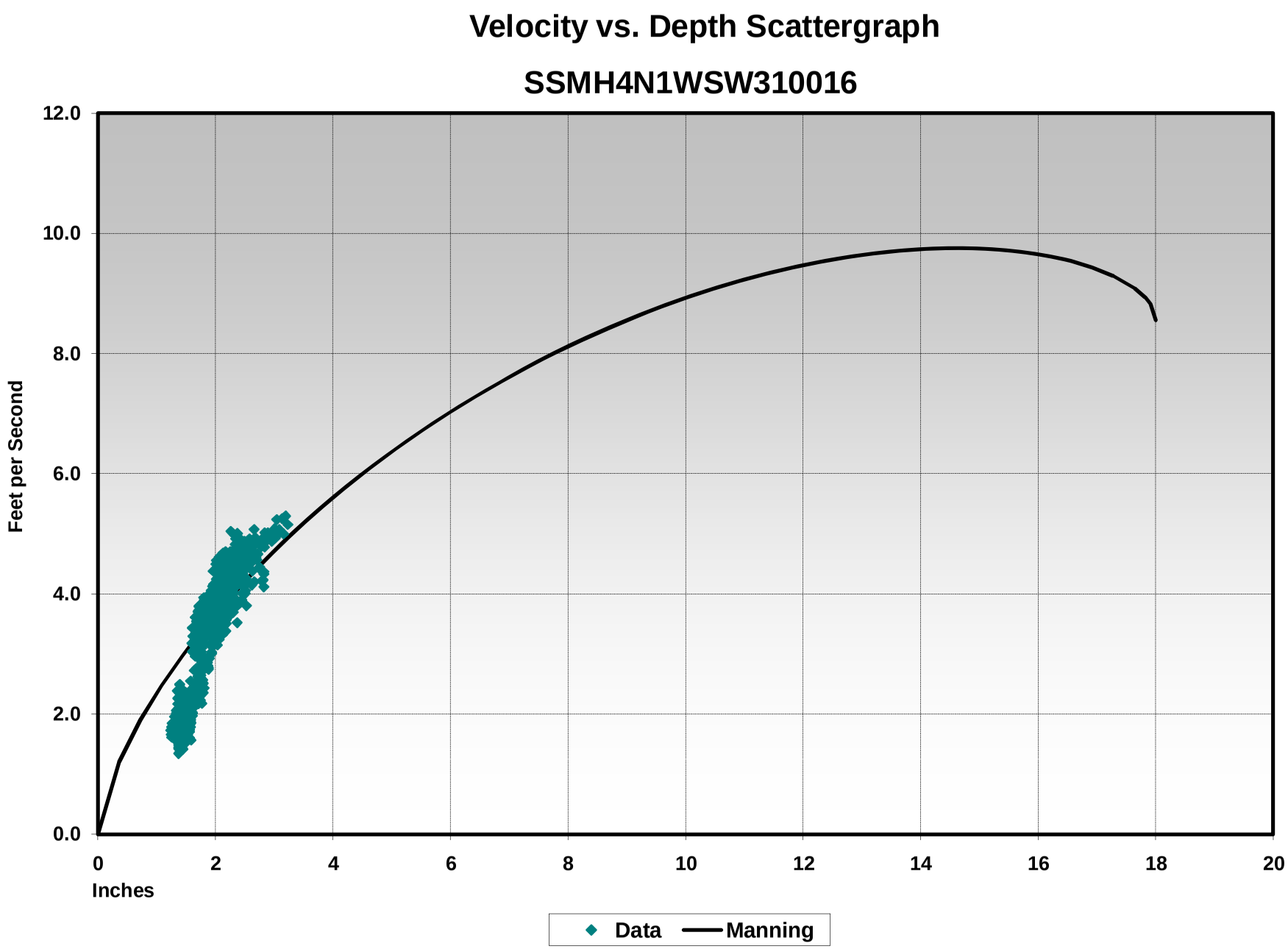
Peak to Average Flow Rate

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

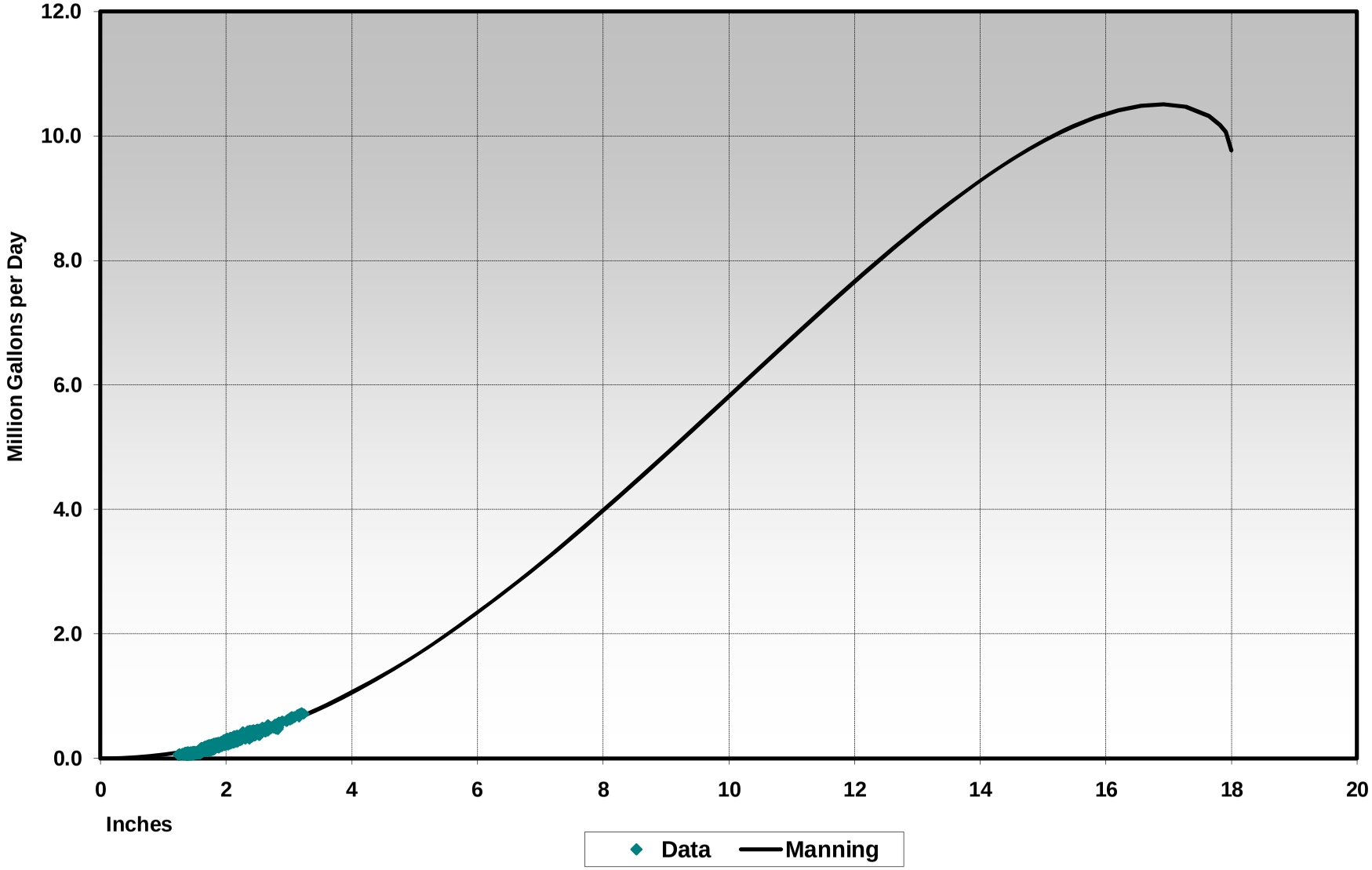
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.88	1.83	2.12	1.80	1.97	1.68	1.85	1.82	2.02	2.20	2.02	1.95	2.01	2.22




Velocity vs. Depth Scattergraph
SSMH4N1WSW310016
Feet per Second
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH4N1WSW310016



Flow Rate - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.22	0.23	0.21	0.17	0.19	0.21	0.21	0.20	0.18	0.19	0.19	0.20	0.18	0.19
1:00	0.15	0.15	0.16	0.14	0.12	0.15	0.15	0.15	0.13	0.13	0.14	0.14	0.12	0.13
2:00	0.08	0.08	0.09	0.07	0.08	0.08	0.09	0.09	0.08	0.08	0.09	0.08	0.09	0.09
3:00	0.07	0.06	0.08	0.07	0.07	0.07	0.08	0.09	0.06	0.08	0.07	0.06	0.07	0.07
4:00	0.07	0.09	0.08	0.07	0.08	0.08	0.09	0.09	0.06	0.08	0.07	0.08	0.07	0.08
5:00	0.11	0.09	0.08	0.07	0.08	0.09	0.09	0.08	0.09	0.09	0.08	0.08	0.07	0.08
6:00	0.15	0.13	0.11	0.09	0.10	0.12	0.15	0.14	0.13	0.10	0.09	0.14	0.13	0.12
7:00	0.26	0.26	0.42	0.15	0.23	0.26	0.28	0.26	0.27	0.34	0.22	0.26	0.27	0.32
8:00	0.40	0.40	0.40	0.28	0.38	0.38	0.40	0.37	0.40	0.59	0.36	0.38	0.36	0.31
9:00	0.45	0.42	0.55	0.42	0.44	0.40	0.43	0.41	0.44	0.65	0.49	0.42	0.39	0.35
10:00	0.40	0.42	0.55	0.43	0.39	0.36	0.41	0.37	0.40	0.70	0.50	0.37	0.36	0.33
11:00	0.38	0.37	0.49	0.41	0.35	0.34	0.35	0.33	0.35	0.61	0.48	0.32	0.31	0.31
12:00	0.30	0.32	0.43	0.40	0.31	0.32	0.30	0.29	0.33	0.54	0.46	0.30	0.32	0.28
13:00	0.30	0.27	0.38	0.37	0.28	0.33	0.29	0.26	0.28	0.49	0.42	0.28	0.22	0.23
14:00	0.29	0.27	0.35	0.33	0.24	0.28	0.26	0.24	0.25	0.41	0.38	0.24	0.21	0.22
15:00	0.26	0.23	0.31	0.31	0.25	0.26	0.25	0.23	0.23	0.39	0.33	0.21	0.19	0.20
16:00	0.23	0.22	0.30	0.29	0.25	0.25	0.23	0.22	0.22	0.36	0.30	0.21	0.19	0.19
17:00	0.23	0.23	0.28	0.29	0.25	0.24	0.22	0.23	0.22	0.32	0.32	0.20	0.19	0.20
18:00	0.26	0.26	0.27	0.27	0.25	0.24	0.23	0.27	0.22	0.34	0.31	0.21	0.20	0.19
19:00	0.26	0.24	0.26	0.28	0.25	0.26	0.26	0.30	0.23	0.33	0.33	0.24	0.21	0.23
20:00	0.29	0.25	0.25	0.29	0.27	0.28	0.28	0.30	0.24	0.32	0.31	0.23	0.23	0.24
21:00	0.28	0.23	0.26	0.28	0.26	0.27	0.27	0.28	0.23	0.30	0.29	0.25	0.23	0.23
22:00	0.27	0.24	0.24	0.26	0.24	0.26	0.26	0.23	0.22	0.26	0.27	0.22	0.23	0.22
23:00	0.28	0.28	0.20	0.24	0.25	0.27	0.28	0.23	0.23	0.24	0.25	0.22	0.23	0.21
Average	0.25	0.24	0.28	0.25	0.23	0.24	0.24	0.24	0.23	0.33	0.28	0.22	0.21	0.21
Median	0.27	0.24	0.27	0.28	0.25	0.26	0.25	0.24	0.23	0.32	0.30	0.22	0.21	0.21
Max Hr. Mean	0.45	0.42	0.55	0.43	0.44	0.40	0.43	0.41	0.44	0.70	0.50	0.42	0.39	0.35
Min Hr. Mean	0.07	0.06	0.08	0.07	0.07	0.07	0.08	0.08	0.06	0.08	0.07	0.06	0.07	0.07
Inst. Max	0.47	0.44	0.60	0.45	0.46	0.40	0.45	0.43	0.47	0.73	0.57	0.44	0.43	0.46
Inst. Min	0.06	0.06	0.07	0.06	0.06	0.06	0.08	0.08	0.05	0.07	0.06	0.06	0.07	0.07

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.51	3.56	3.39	2.89	3.54	3.50	3.50	3.35	3.28	3.38	3.28	3.37	3.27	3.34
1:00	2.81	2.53	2.74	2.47	2.40	2.66	2.58	2.60	2.55	2.48	2.69	2.48	2.38	2.60
2:00	1.93	1.71	1.94	1.60	2.03	1.93	1.88	1.85	1.76	1.94	2.16	1.99	1.87	1.91
3:00	1.67	1.48	1.96	1.67	1.76	1.64	1.77	1.80	1.48	1.98	1.81	1.71	1.72	1.70
4:00	1.70	1.77	1.90	1.60	1.92	1.79	1.88	1.83	1.53	2.05	1.73	1.84	1.70	1.75
5:00	2.14	1.79	1.99	1.64	1.95	1.95	1.91	1.82	1.89	2.19	1.79	1.79	1.78	1.76
6:00	2.87	2.39	2.24	1.90	2.12	2.26	2.68	2.48	2.45	2.37	2.06	2.56	2.51	2.49
7:00	4.01	3.80	4.18	2.53	3.82	3.89	3.93	3.85	3.97	4.00	3.48	3.90	3.77	4.09
8:00	4.67	4.65	4.38	3.83	4.76	4.59	4.55	4.47	4.68	4.96	4.30	4.41	4.31	4.37
9:00	4.71	4.57	4.98	4.83	4.78	4.57	4.55	4.53	4.74	5.03	4.70	4.55	4.42	4.54
10:00	4.45	4.62	4.76	4.78	4.62	4.33	4.49	4.34	4.58	5.20	4.81	4.38	4.38	4.37
11:00	4.40	4.36	4.34	4.67	4.40	4.13	4.07	4.22	4.21	4.97	4.62	4.08	4.23	4.19
12:00	3.98	4.04	4.09	4.56	4.11	4.01	3.90	3.87	4.05	4.80	4.53	4.06	4.27	3.92
13:00	3.93	3.75	3.99	4.39	3.92	4.09	3.78	3.71	3.81	4.67	4.31	3.87	3.71	3.56
14:00	3.70	3.77	3.85	4.25	3.64	3.83	3.68	3.60	3.67	4.36	4.19	3.68	3.68	3.57
15:00	3.79	3.55	3.74	4.14	3.73	3.79	3.61	3.53	3.62	4.22	3.92	3.48	3.51	3.46
16:00	3.61	3.58	3.72	4.07	3.68	3.68	3.53	3.54	3.61	4.15	3.94	3.51	3.45	3.36
17:00	3.61	3.55	3.64	4.04	3.74	3.64	3.54	3.62	3.56	3.96	4.01	3.47	3.42	3.56
18:00	3.76	3.50	3.45	3.96	3.72	3.63	3.61	3.76	3.63	4.09	3.94	3.61	3.47	3.45
19:00	3.79	3.47	3.47	4.05	3.71	3.77	3.73	3.98	3.63	4.02	4.11	3.74	3.74	3.70
20:00	3.98	3.47	3.39	4.04	3.89	3.87	3.95	4.00	3.73	3.96	3.89	3.68	3.69	3.85
21:00	3.89	3.46	3.50	4.08	3.82	3.80	3.83	3.85	3.75	3.87	3.88	3.88	3.73	3.63
22:00	3.80	3.43	3.32	4.00	3.66	3.80	3.77	3.56	3.63	3.72	3.74	3.60	3.64	3.62
23:00	3.86	3.57	3.02	3.86	3.81	3.82	3.90	3.65	3.70	3.59	3.77	3.66	3.71	3.66
Average	3.52	3.35	3.42	3.49	3.48	3.46	3.44	3.41	3.40	3.75	3.57	3.39	3.35	3.35
Median	3.76	3.53	3.52	3.99	3.73	3.76	3.69	3.67	3.62	3.95	3.90	3.63	3.60	3.53
Max Hr. Mean	4.71	4.65	4.98	4.83	4.78	4.59	4.55	4.53	4.74	5.20	4.81	4.55	4.42	4.54
Min Hr. Mean	1.67	1.48	1.90	1.60	1.76	1.64	1.77	1.80	1.48	1.94	1.73	1.71	1.70	1.70
Inst. Max	4.88	4.79	5.07	5.01	5.04	4.70	4.69	4.69	4.81	5.30	4.94	4.64	4.55	4.79
Inst. Min	1.58	1.38	1.79	1.44	1.56	1.49	1.57	1.65	1.34	1.89	1.63	1.51	1.60	1.63

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N1WSW310016

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.85	1.90	1.83	1.76	1.68	1.79	1.83	1.82	1.72	1.70	1.75	1.81	1.71	1.74
1:00	1.65	1.75	1.73	1.70	1.58	1.70	1.72	1.78	1.65	1.65	1.63	1.72	1.63	1.61
2:00	1.41	1.47	1.49	1.41	1.36	1.43	1.51	1.54	1.56	1.39	1.46	1.42	1.53	1.49
3:00	1.40	1.41	1.45	1.42	1.36	1.47	1.55	1.55	1.41	1.38	1.39	1.26	1.41	1.41
4:00	1.42	1.55	1.45	1.42	1.38	1.47	1.55	1.54	1.41	1.40	1.39	1.46	1.42	1.50
5:00	1.56	1.56	1.43	1.43	1.38	1.49	1.51	1.52	1.58	1.37	1.43	1.44	1.40	1.51
6:00	1.68	1.66	1.56	1.48	1.54	1.61	1.71	1.70	1.68	1.40	1.42	1.63	1.57	1.55
7:00	1.92	1.95	2.55	1.81	1.79	1.92	2.01	1.97	1.97	2.25	1.89	1.95	2.02	2.14
8:00	2.31	2.32	2.41	2.06	2.20	2.26	2.34	2.26	2.31	2.87	2.26	2.30	2.27	2.04
9:00	2.48	2.41	2.74	2.33	2.43	2.35	2.49	2.41	2.45	3.07	2.66	2.43	2.37	2.16
10:00	2.37	2.40	2.83	2.39	2.30	2.28	2.40	2.30	2.35	3.15	2.64	2.29	2.25	2.11
11:00	2.31	2.28	2.81	2.36	2.20	2.23	2.29	2.19	2.28	2.96	2.64	2.18	2.08	2.09
12:00	2.14	2.21	2.65	2.34	2.13	2.20	2.17	2.10	2.23	2.79	2.61	2.10	2.08	2.03
13:00	2.12	2.06	2.48	2.26	2.06	2.21	2.12	2.01	2.09	2.66	2.52	2.08	1.82	1.89
14:00	2.20	2.02	2.38	2.15	1.95	2.08	2.02	1.94	1.96	2.47	2.40	1.92	1.76	1.82
15:00	2.00	1.93	2.26	2.11	1.96	1.98	1.99	1.90	1.88	2.41	2.26	1.83	1.72	1.77
16:00	1.87	1.85	2.22	2.05	1.94	1.96	1.92	1.85	1.83	2.33	2.15	1.81	1.68	1.75
17:00	1.86	1.92	2.15	2.02	1.92	1.94	1.84	1.90	1.83	2.22	2.22	1.78	1.72	1.74
18:00	2.00	2.07	2.16	1.98	1.95	1.95	1.88	2.06	1.85	2.25	2.16	1.80	1.77	1.74
19:00	2.00	2.02	2.12	2.01	1.93	2.00	1.98	2.10	1.90	2.26	2.20	1.92	1.75	1.86
20:00	2.04	2.03	2.07	2.03	2.01	2.04	2.05	2.13	1.89	2.24	2.18	1.85	1.84	1.86
21:00	2.04	1.94	2.08	1.97	1.99	2.03	2.01	2.07	1.84	2.15	2.10	1.91	1.83	1.86
22:00	2.02	2.04	2.06	1.92	1.94	1.98	1.99	1.91	1.82	2.01	2.03	1.84	1.89	1.81
23:00	2.04	2.14	1.92	1.83	1.92	2.00	2.03	1.88	1.85	1.94	1.96	1.79	1.84	1.77
Average	1.95	1.95	2.12	1.93	1.87	1.93	1.95	1.93	1.89	2.18	2.06	1.85	1.81	1.80
Median	2.01	2.00	2.12	1.99	1.95	1.98	1.97	1.93	1.85	2.24	2.15	1.83	1.78	1.79
Max Hr. Mean	2.48	2.41	2.83	2.39	2.43	2.35	2.49	2.41	2.45	3.15	2.66	2.43	2.37	2.16
Min Hr. Mean	1.40	1.41	1.43	1.41	1.36	1.43	1.51	1.52	1.41	1.37	1.39	1.26	1.40	1.41
Inst. Max	2.50	2.44	2.90	2.42	2.45	2.41	2.52	2.47	2.52	3.24	2.86	2.50	2.48	2.51
Inst. Min	1.38	1.39	1.36	1.36	1.34	1.41	1.48	1.47	1.37	1.31	1.26	1.25	1.37	1.39

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 13
Address: W Cactus W of N 153rd Avenue
MH ID# SSMH3N1WSW170115

Date: 6/11/2008
GPS: 33.354215N -112.232164W

Overview

Street Level - Night Photo

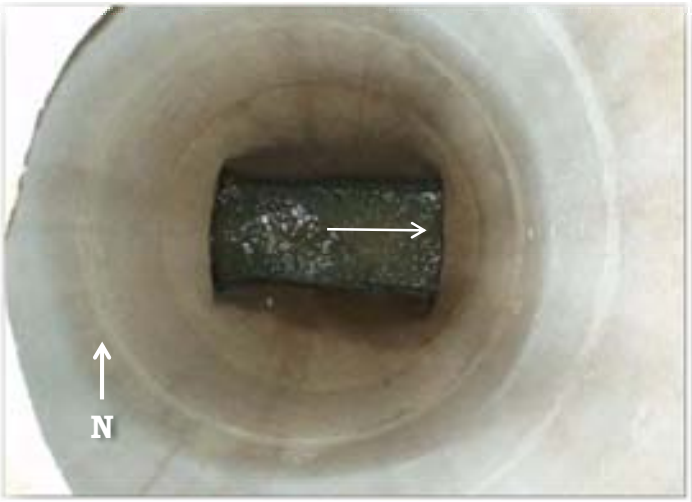
Meter Details

Meter Type	2150
Serial #	204L00442
Sensor Serial #	202D01608
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	30"	Horiz.	30"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole

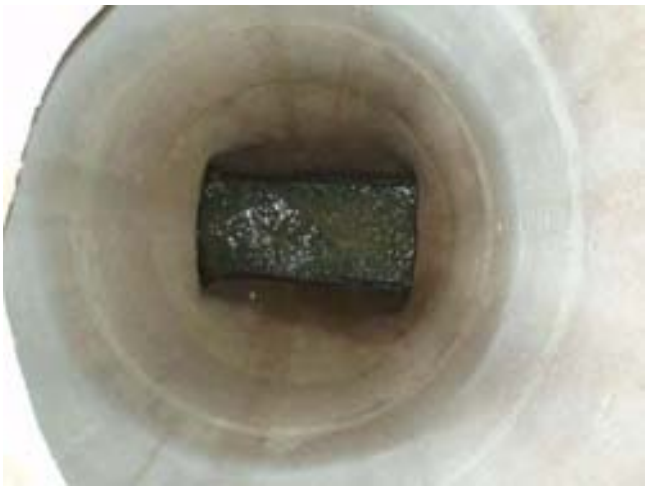


Hydraulics:
Fast flow conditions. Quick flow changes.

Comments:
Lots of turbulence in bench area

Photos
MH #SSMH3N1WSW170115
Site #13

Site ID



Down Manhole

30” Influent

30” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

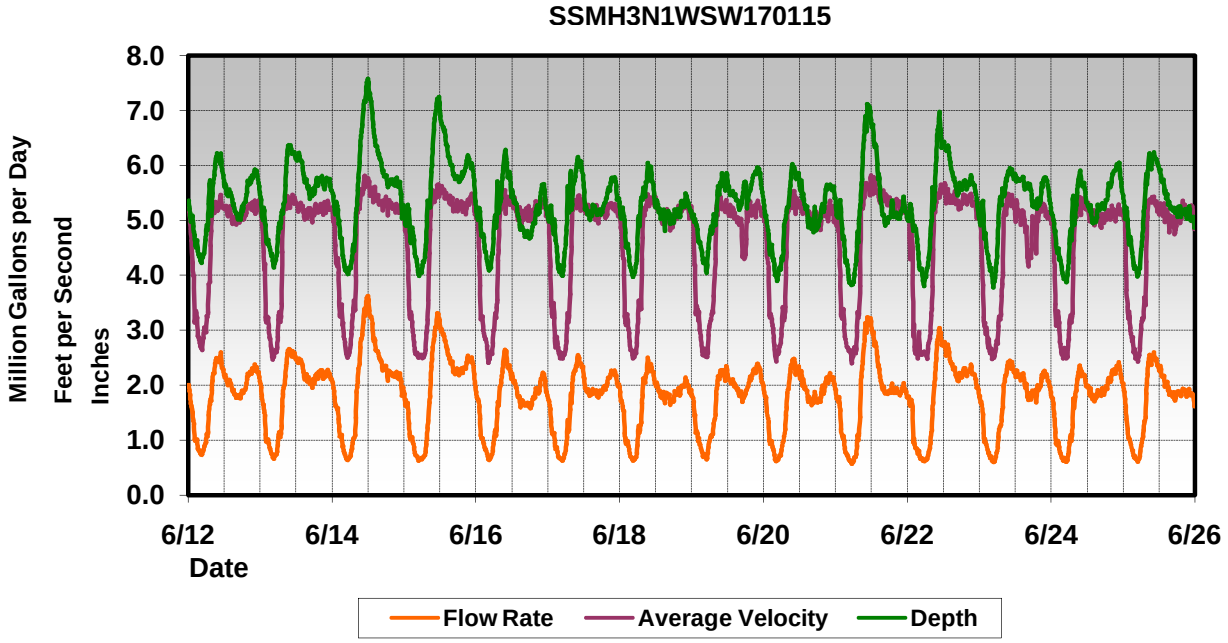
Site	**SSMH3N1WSW170115**	
Address	**Cactus Rd W of 153 Avenue**	
Diameter	**30**	Inches
GPS	**33.354215N**	**-112.232164W**

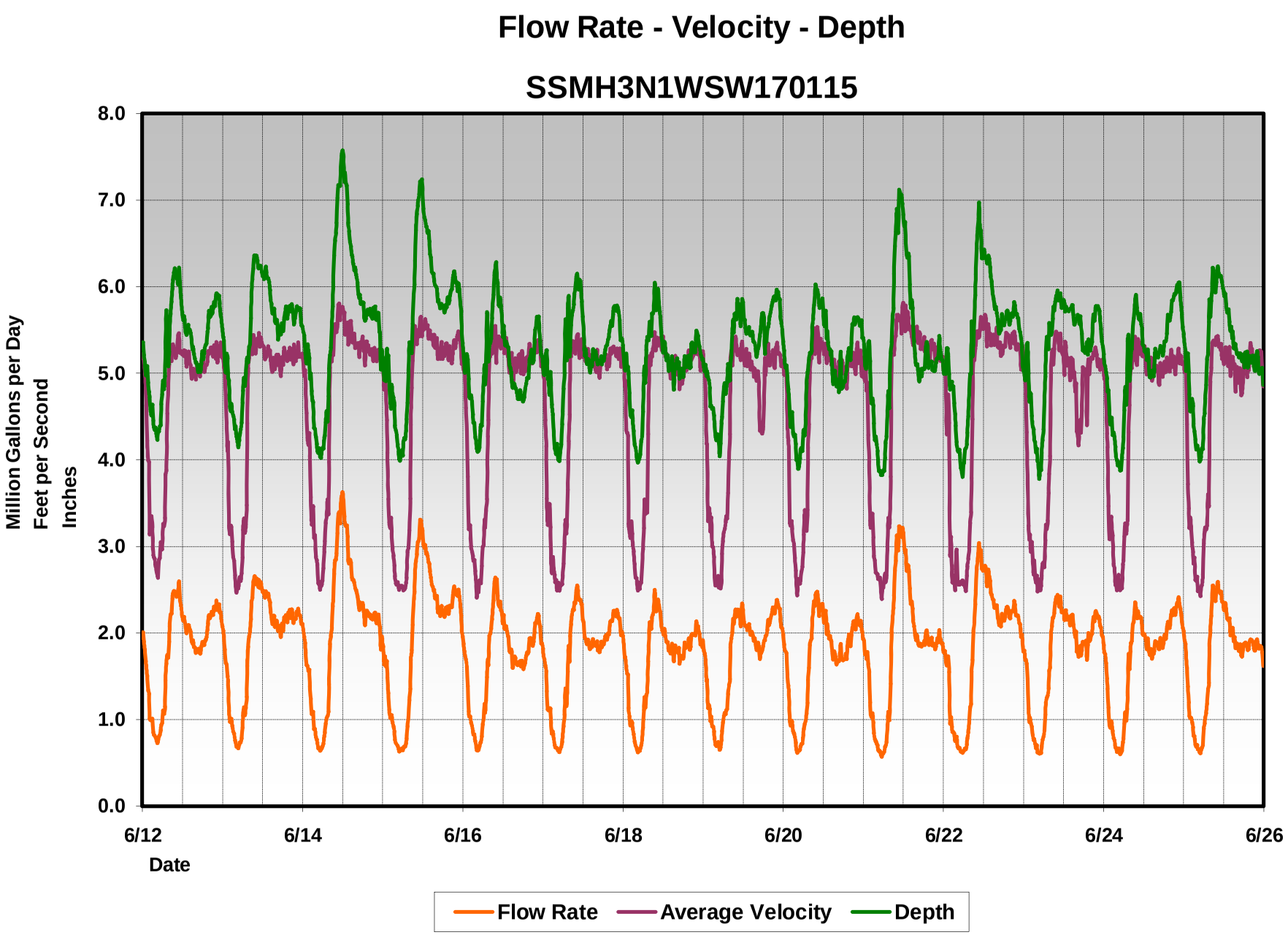
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	5.30
Maximum	7.57
Minimum	3.78
Max d/D	25.2%

Flow velocity	
	Feet per Second
Average	4.59
Maximum	5.81
Minimum	2.39

Flow Rate	
	Million Gallons per Day
Average	1.80
Maximum	3.62
Minimum	0.57
Peak Factor	2.01



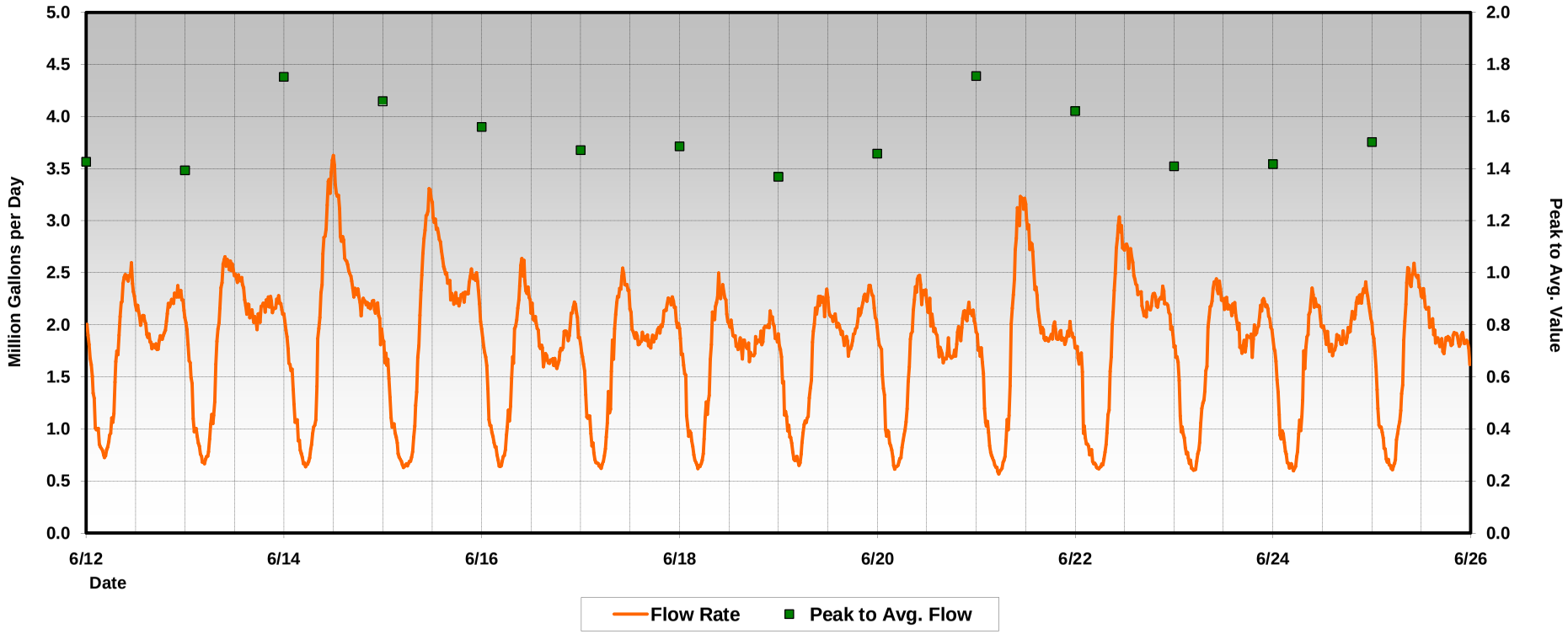

Flow Rate - Velocity - Depth
SSMH3N1WSW170115
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

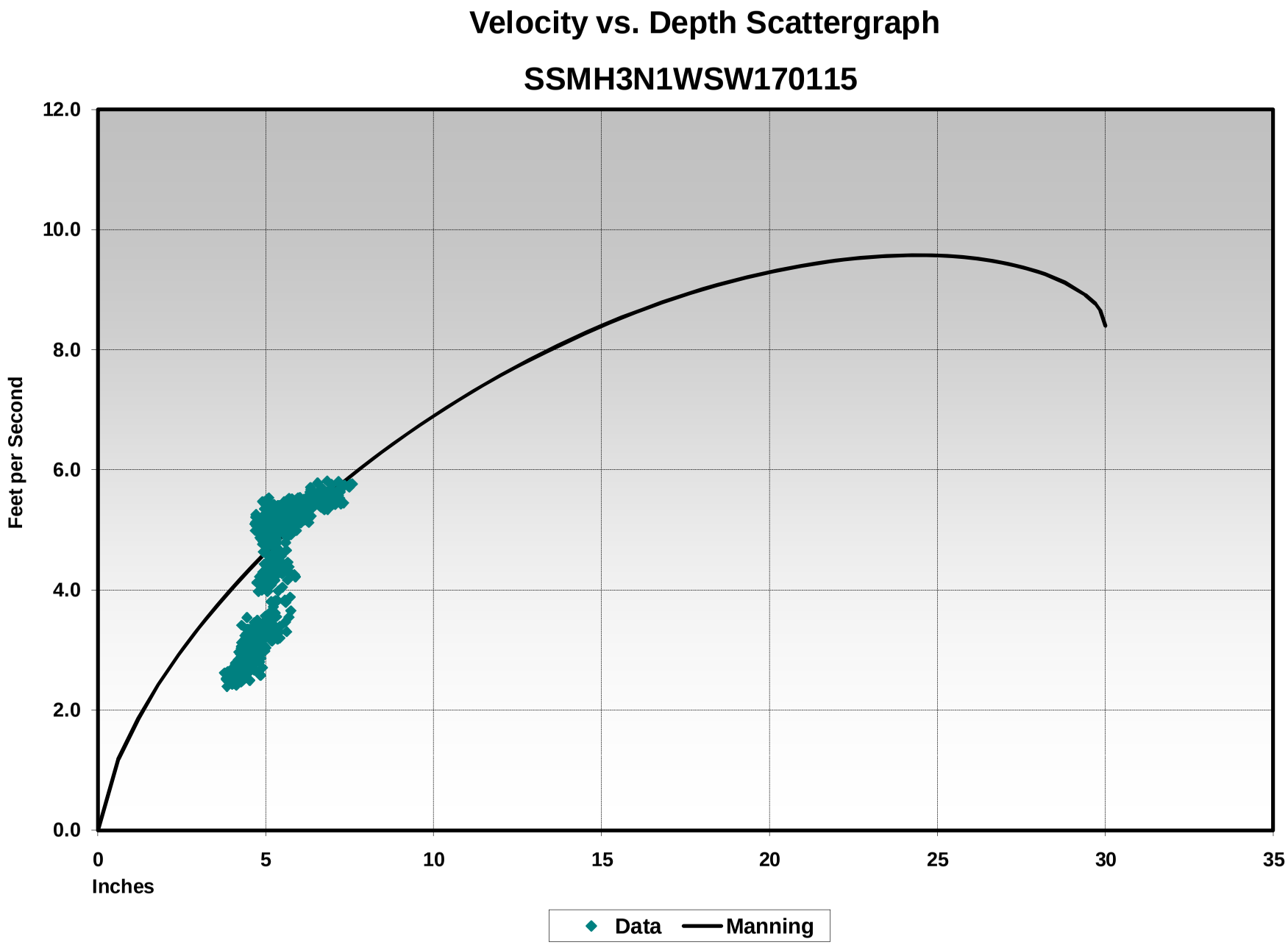
Peak to Average Flow Rate

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

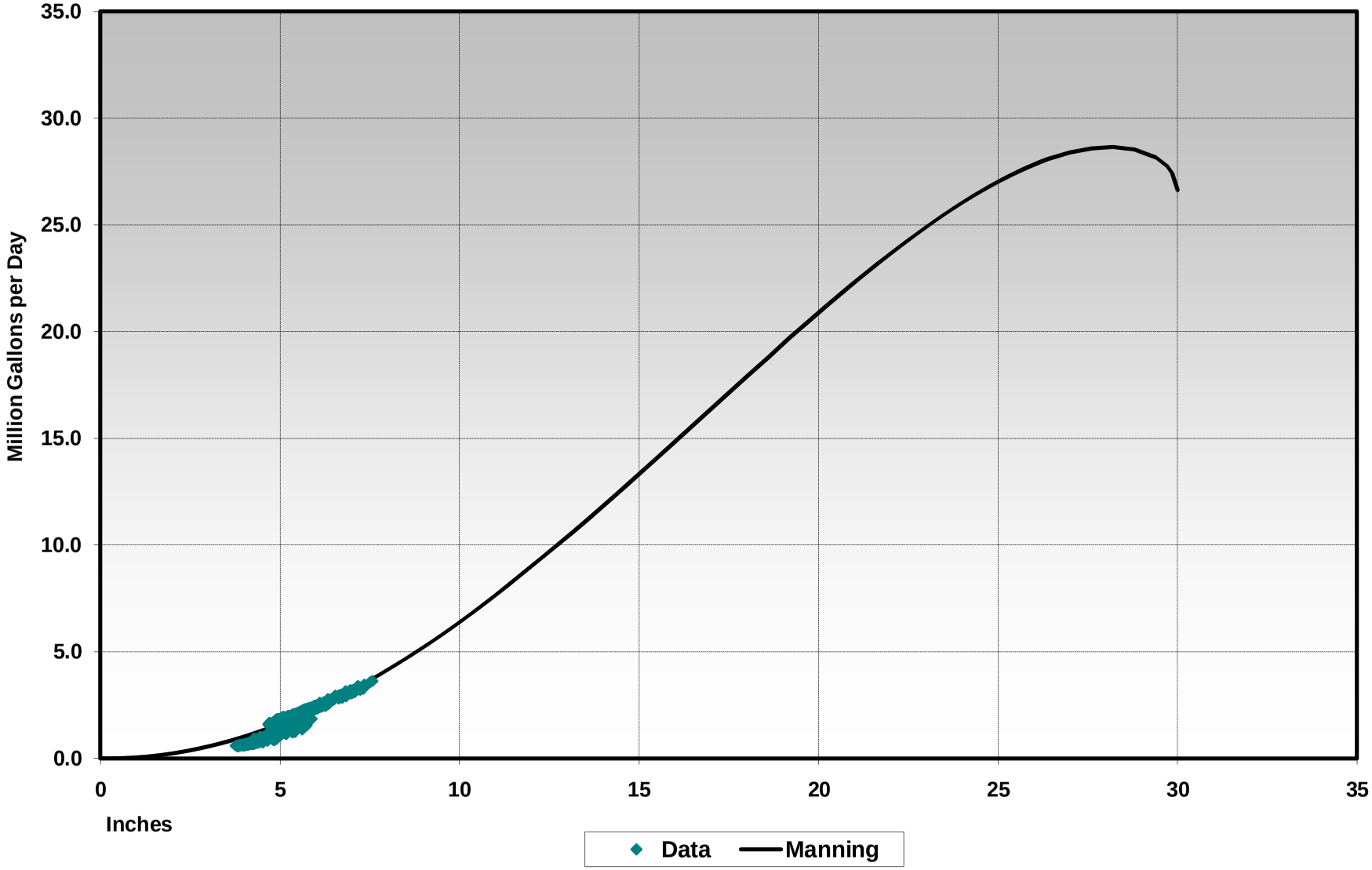
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.43	1.39	1.75	1.66	1.56	1.47	1.48	1.37	1.46	1.76	1.62	1.41	1.42	1.50




Velocity vs. Depth Scattergraph
SSMH3N1WSW170115
12.0
10.0
8.0
6.0
4.0
2.0
0.0
Feet per Second
0
5
10
15
20
25
30
35
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH3N1WSW170115



Flow Rate - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.92	1.96	1.99	1.77	1.84	1.72	1.82	1.79	1.86	1.84	1.76	1.74	1.76	1.89
1:00	1.53	1.56	1.64	1.52	1.44	1.28	1.45	1.30	1.50	1.66	1.65	1.30	1.23	1.30
2:00	1.07	1.02	1.31	1.05	0.99	1.01	0.98	1.01	0.97	1.09	0.94	0.93	0.93	0.98
3:00	0.87	0.85	0.98	0.88	0.82	0.75	0.79	0.82	0.81	0.83	0.81	0.73	0.72	0.75
4:00	0.75	0.69	0.74	0.70	0.66	0.66	0.65	0.71	0.63	0.68	0.71	0.64	0.64	0.66
5:00	0.86	0.74	0.66	0.65	0.74	0.68	0.69	0.74	0.69	0.60	0.63	0.67	0.65	0.66
6:00	1.07	1.04	0.77	0.67	1.05	1.04	1.10	1.04	0.91	0.65	0.65	0.98	0.95	0.99
7:00	1.64	1.46	1.02	0.87	1.51	1.44	1.52	1.23	1.33	0.93	0.83	1.36	1.43	1.45
8:00	2.10	2.12	1.83	1.52	2.04	1.99	2.11	1.81	1.96	1.68	1.39	1.96	1.92	2.30
9:00	2.45	2.57	2.55	2.40	2.45	2.31	2.32	2.18	2.34	2.57	2.24	2.29	2.25	2.45
10:00	2.45	2.58	3.07	2.96	2.46	2.47	2.32	2.24	2.38	3.10	2.89	2.37	2.20	2.51
11:00	2.40	2.56	3.43	3.22	2.29	2.36	2.16	2.22	2.31	3.19	2.83	2.31	2.11	2.41
12:00	2.16	2.45	3.44	3.05	2.10	2.04	2.00	2.14	2.18	3.01	2.75	2.23	1.94	2.29
13:00	2.05	2.45	3.11	2.89	2.00	1.90	1.87	2.07	2.01	2.75	2.64	2.17	1.83	2.16
14:00	2.01	2.29	2.77	2.68	1.79	1.82	1.81	2.01	1.89	2.37	2.47	2.16	1.76	2.01
15:00	1.87	2.14	2.58	2.48	1.67	1.89	1.79	1.92	1.74	2.04	2.32	2.02	1.83	1.89
16:00	1.79	2.08	2.43	2.35	1.65	1.84	1.80	1.84	1.67	1.91	2.18	1.78	1.84	1.84
17:00	1.80	2.04	2.30	2.26	1.66	1.84	1.70	1.76	1.75	1.86	2.15	1.82	1.88	1.79
18:00	1.88	2.12	2.23	2.22	1.62	1.91	1.78	1.91	1.71	1.91	2.19	1.89	1.93	1.87
19:00	2.00	2.19	2.23	2.27	1.76	1.97	1.87	2.06	1.86	1.93	2.26	1.86	2.08	1.84
20:00	2.21	2.22	2.19	2.30	1.93	2.11	1.90	2.19	1.95	1.90	2.23	1.99	2.19	1.91
21:00	2.25	2.17	2.20	2.47	1.97	2.24	1.98	2.26	2.09	1.85	2.29	2.20	2.27	1.83
22:00	2.30	2.22	2.17	2.46	2.17	2.21	2.07	2.34	2.15	1.94	2.18	2.18	2.35	1.86
23:00	2.24	2.16	1.98	2.24	1.98	2.05	1.89	2.14	2.07	1.90	1.98	2.02	2.17	1.77
Average	1.82	1.90	2.07	1.99	1.69	1.73	1.68	1.74	1.70	1.84	1.87	1.73	1.70	1.72
Median	1.92	2.13	2.20	2.27	1.77	1.89	1.83	1.94	1.83	1.88	2.15	1.92	1.87	1.85
Max Hr. Mean	2.45	2.58	3.44	3.22	2.46	2.47	2.32	2.34	2.38	3.19	2.89	2.37	2.35	2.51
Min Hr. Mean	0.75	0.69	0.66	0.65	0.66	0.66	0.65	0.71	0.63	0.60	0.63	0.64	0.64	0.66
Inst. Max	2.60	2.65	3.62	3.31	2.64	2.54	2.50	2.38	2.48	3.23	3.04	2.44	2.41	2.59
Inst. Min	0.73	0.67	0.64	0.63	0.64	0.62	0.62	0.65	0.61	0.57	0.62	0.61	0.60	0.61

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.14	5.11	5.09	4.99	5.04	4.85	5.02	5.03	5.04	4.98	5.03	5.00	4.90	5.03
1:00	4.42	4.37	4.45	4.21	3.99	3.56	4.05	3.78	4.43	4.49	4.51	3.61	3.75	3.69
2:00	3.43	3.21	3.79	3.24	3.10	3.07	3.18	3.22	3.25	3.29	2.83	2.99	3.20	3.14
3:00	2.96	2.86	3.26	2.82	2.82	2.72	2.85	2.77	2.92	2.88	2.62	2.69	2.68	2.72
4:00	2.69	2.52	2.77	2.56	2.48	2.55	2.57	2.59	2.56	2.65	2.68	2.57	2.57	2.52
5:00	2.94	2.63	2.55	2.53	2.64	2.54	2.61	2.65	2.66	2.52	2.59	2.62	2.59	2.55
6:00	3.20	3.14	2.83	2.51	3.13	2.95	3.27	3.18	3.21	2.60	2.54	2.97	3.09	3.15
7:00	4.26	4.05	3.38	2.78	3.92	3.57	3.94	3.58	3.79	3.04	2.82	3.49	3.88	3.64
8:00	5.19	5.26	4.85	3.99	5.22	5.05	5.18	4.95	5.17	4.39	3.73	4.90	5.11	5.17
9:00	5.29	5.35	5.41	5.37	5.42	5.29	5.34	5.32	5.39	5.36	5.25	5.32	5.28	5.37
10:00	5.29	5.33	5.58	5.41	5.32	5.39	5.35	5.25	5.39	5.65	5.45	5.38	5.28	5.35
11:00	5.30	5.38	5.73	5.54	5.36	5.26	5.34	5.28	5.35	5.62	5.59	5.32	5.25	5.25
12:00	5.22	5.27	5.66	5.54	5.37	5.24	5.30	5.17	5.28	5.69	5.59	5.20	5.19	5.21
13:00	5.17	5.24	5.51	5.50	5.26	5.21	5.17	5.19	5.20	5.59	5.46	5.13	5.06	5.16
14:00	5.10	5.17	5.49	5.46	5.11	5.17	5.04	5.10	5.16	5.46	5.36	5.05	5.06	5.08
15:00	5.02	5.10	5.39	5.37	5.04	5.09	5.12	5.01	5.07	5.37	5.41	4.92	5.08	4.98
16:00	5.03	5.17	5.33	5.30	5.10	5.08	5.04	4.94	5.01	5.46	5.37	4.31	4.98	5.00
17:00	5.06	5.10	5.29	5.27	5.14	5.09	4.89	4.35	5.11	5.34	5.27	4.60	5.00	4.86
18:00	5.06	5.19	5.28	5.23	5.05	5.18	5.05	4.80	5.04	5.32	5.35	5.03	5.06	5.13
19:00	5.14	5.18	5.33	5.27	5.18	5.12	5.16	5.17	5.06	5.24	5.43	4.90	5.09	5.06
20:00	5.25	5.23	5.24	5.20	5.23	5.23	5.15	5.17	5.14	5.30	5.38	5.16	5.15	5.25
21:00	5.28	5.23	5.22	5.30	5.22	5.27	5.26	5.18	5.11	5.24	5.38	5.25	5.13	5.16
22:00	5.21	5.23	5.21	5.42	5.29	5.22	5.28	5.28	5.23	5.21	5.30	5.14	5.19	5.18
23:00	5.26	5.20	5.21	5.28	5.21	5.20	5.12	5.16	5.14	5.17	5.22	5.12	5.15	5.09
Average	4.66	4.65	4.74	4.59	4.61	4.54	4.59	4.50	4.61	4.66	4.59	4.45	4.53	4.53
Median	5.10	5.18	5.23	5.24	5.12	5.14	5.10	5.06	5.08	5.22	5.29	5.03	5.05	5.07
Max Hr. Mean	5.30	5.38	5.73	5.54	5.42	5.39	5.35	5.32	5.39	5.69	5.59	5.38	5.28	5.37
Min Hr. Mean	2.69	2.52	2.55	2.51	2.48	2.54	2.57	2.59	2.56	2.52	2.54	2.57	2.57	2.52
Inst. Max	5.46	5.47	5.81	5.65	5.54	5.45	5.47	5.42	5.53	5.81	5.67	5.48	5.42	5.43
Inst. Min	2.64	2.47	2.50	2.50	2.41	2.49	2.49	2.51	2.43	2.39	2.49	2.48	2.49	2.43

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N1WSW170115

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	5.25	5.36	5.43	5.06	5.17	5.07	5.14	5.09	5.21	5.22	5.02	5.01	5.11	5.26
1:00	4.99	5.09	5.23	5.14	5.13	5.10	5.09	4.97	4.90	5.23	5.19	5.08	4.78	5.03
2:00	4.65	4.68	4.98	4.76	4.71	4.82	4.59	4.66	4.50	4.83	4.84	4.61	4.41	4.64
3:00	4.45	4.47	4.52	4.62	4.41	4.27	4.28	4.45	4.27	4.39	4.61	4.22	4.19	4.27
4:00	4.30	4.25	4.16	4.22	4.14	4.07	4.01	4.26	3.96	4.03	4.13	3.96	3.96	4.10
5:00	4.44	4.32	4.07	4.04	4.32	4.17	4.15	4.29	4.09	3.84	3.91	4.02	3.98	4.07
6:00	4.86	4.81	4.20	4.18	4.88	5.00	4.88	4.78	4.35	3.99	4.04	4.80	4.58	4.64
7:00	5.37	5.11	4.54	4.61	5.35	5.49	5.37	4.95	5.02	4.54	4.44	5.42	5.17	5.46
8:00	5.56	5.54	5.27	5.30	5.42	5.43	5.58	5.17	5.31	5.29	5.20	5.51	5.27	5.92
9:00	6.11	6.25	6.18	5.94	6.01	5.85	5.84	5.61	5.84	6.25	5.76	5.80	5.78	6.03
10:00	6.11	6.31	6.89	6.86	6.06	6.06	5.83	5.76	5.91	6.88	6.71	5.89	5.67	6.16
11:00	6.00	6.22	7.30	7.17	5.77	5.97	5.55	5.70	5.81	7.03	6.49	5.83	5.52	6.07
12:00	5.65	6.13	7.40	6.89	5.43	5.41	5.29	5.64	5.63	6.70	6.37	5.78	5.27	5.88
13:00	5.49	6.14	7.01	6.66	5.32	5.16	5.14	5.50	5.38	6.36	6.30	5.73	5.13	5.69
14:00	5.46	5.91	6.50	6.35	5.03	5.05	5.12	5.45	5.19	5.84	6.08	5.77	5.00	5.48
15:00	5.24	5.70	6.25	6.09	4.85	5.23	5.02	5.34	4.95	5.31	5.79	5.61	5.13	5.31
16:00	5.09	5.54	6.05	5.91	4.75	5.15	5.10	5.26	4.85	5.03	5.57	5.63	5.22	5.20
17:00	5.07	5.52	5.85	5.79	4.74	5.14	5.00	5.55	4.95	5.01	5.58	5.48	5.27	5.19
18:00	5.23	5.60	5.72	5.74	4.73	5.20	5.05	5.50	4.91	5.11	5.59	5.27	5.34	5.17
19:00	5.42	5.72	5.69	5.81	4.93	5.36	5.15	5.50	5.19	5.20	5.67	5.32	5.60	5.16
20:00	5.70	5.75	5.69	5.92	5.21	5.55	5.21	5.74	5.32	5.11	5.65	5.37	5.76	5.17
21:00	5.76	5.65	5.72	6.12	5.28	5.74	5.29	5.86	5.59	5.05	5.75	5.70	5.92	5.08
22:00	5.90	5.75	5.66	6.02	5.62	5.74	5.43	5.93	5.62	5.24	5.62	5.75	6.01	5.11
23:00	5.75	5.66	5.31	5.75	5.33	5.45	5.22	5.65	5.54	5.20	5.32	5.46	5.71	5.00
Average	5.33	5.48	5.65	5.62	5.11	5.23	5.10	5.28	5.10	5.28	5.40	5.29	5.16	5.21
Median	5.35	5.62	5.68	5.80	5.11	5.21	5.15	5.44	5.16	5.13	5.58	5.49	5.25	5.20
Max Hr. Mean	6.11	6.31	7.40	7.17	6.06	6.06	5.84	5.93	5.91	7.03	6.71	5.89	6.01	6.16
Min Hr. Mean	4.30	4.25	4.07	4.04	4.14	4.07	4.01	4.26	3.96	3.84	3.91	3.96	3.96	4.07
Inst. Max	6.22	6.36	7.57	7.24	6.28	6.15	6.04	5.96	6.03	7.12	6.97	5.96	6.05	6.23
Inst. Min	4.23	4.15	4.02	3.99	4.09	3.99	3.97	4.04	3.90	3.83	3.81	3.78	3.88	3.98

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 14**	**Date:**	**6/10/2008**
Address:	**Greenway Road E of Hwy 303**	**GPS:**	**33.372747N -112.250377W**
MH ID#	**SSMH3N2WSE010107**		

Overview

Street Level

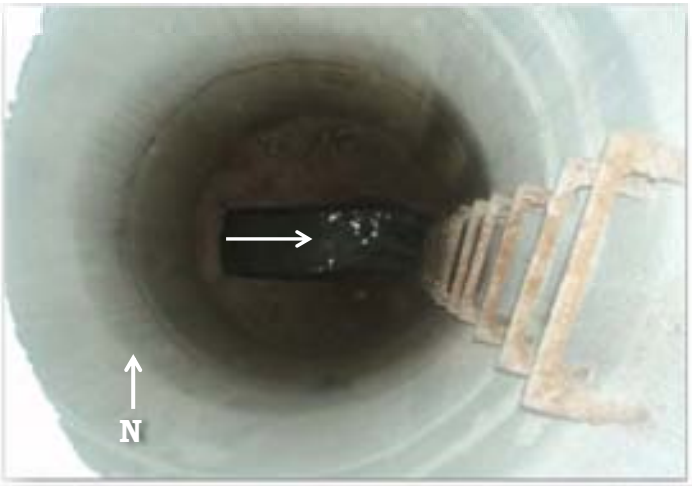
Meter Details

Meter Type	**2150**
Serial #	**203C00492**
Sensor Serial #	**203C01043**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**18"**	**Horiz.**	**18"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole



Hydraulics:
Slow flow conditions. Moderate depth.

Comments:

Photos
MH #SSMH3N2WSE010107
Site #14

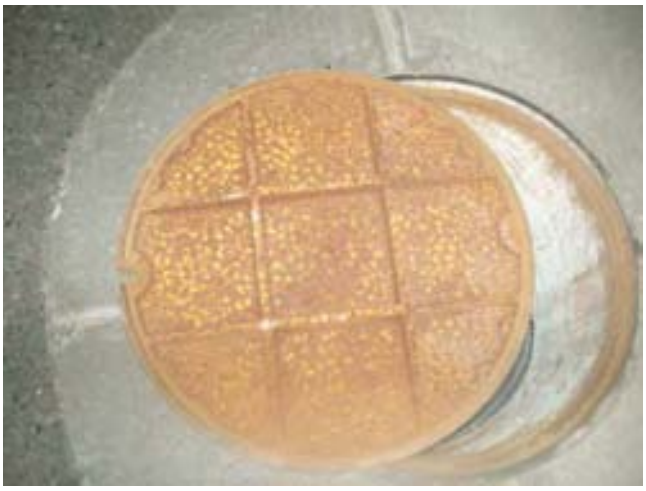
Site ID

Down Manhole

18” Influent

18” Effluent

Manhole Cover Top


Manhole Cover Bottom

Location Summary

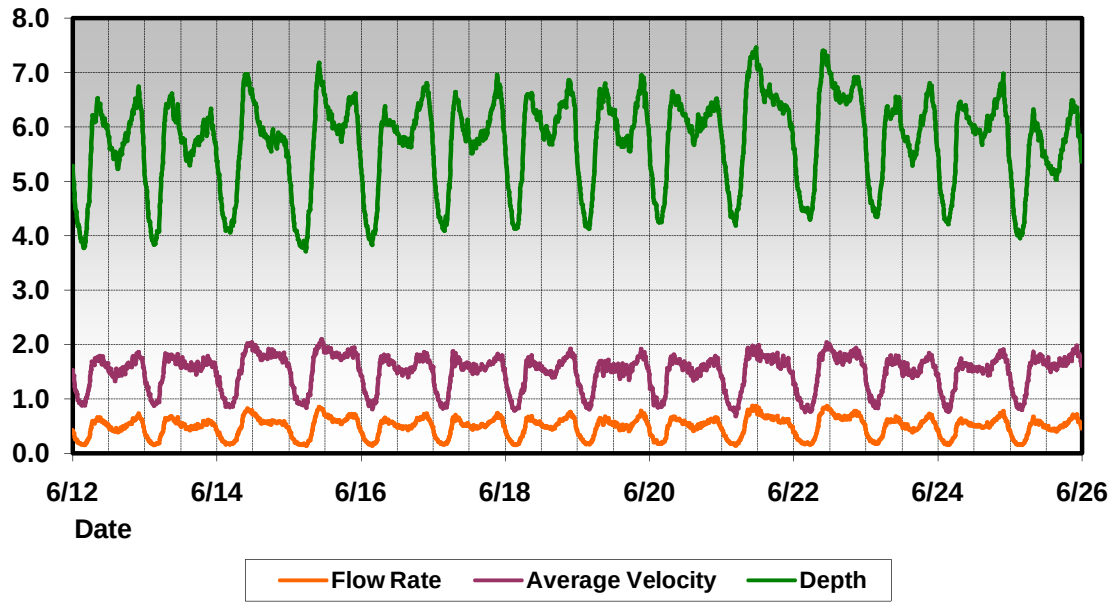
Site	**SSMH3N2WSE010107**	
Address	**Greenway Rd E of Hwy 303**	
Diameter	**18**	Inches
GPS	**33.372747N**	**-112.250377W**

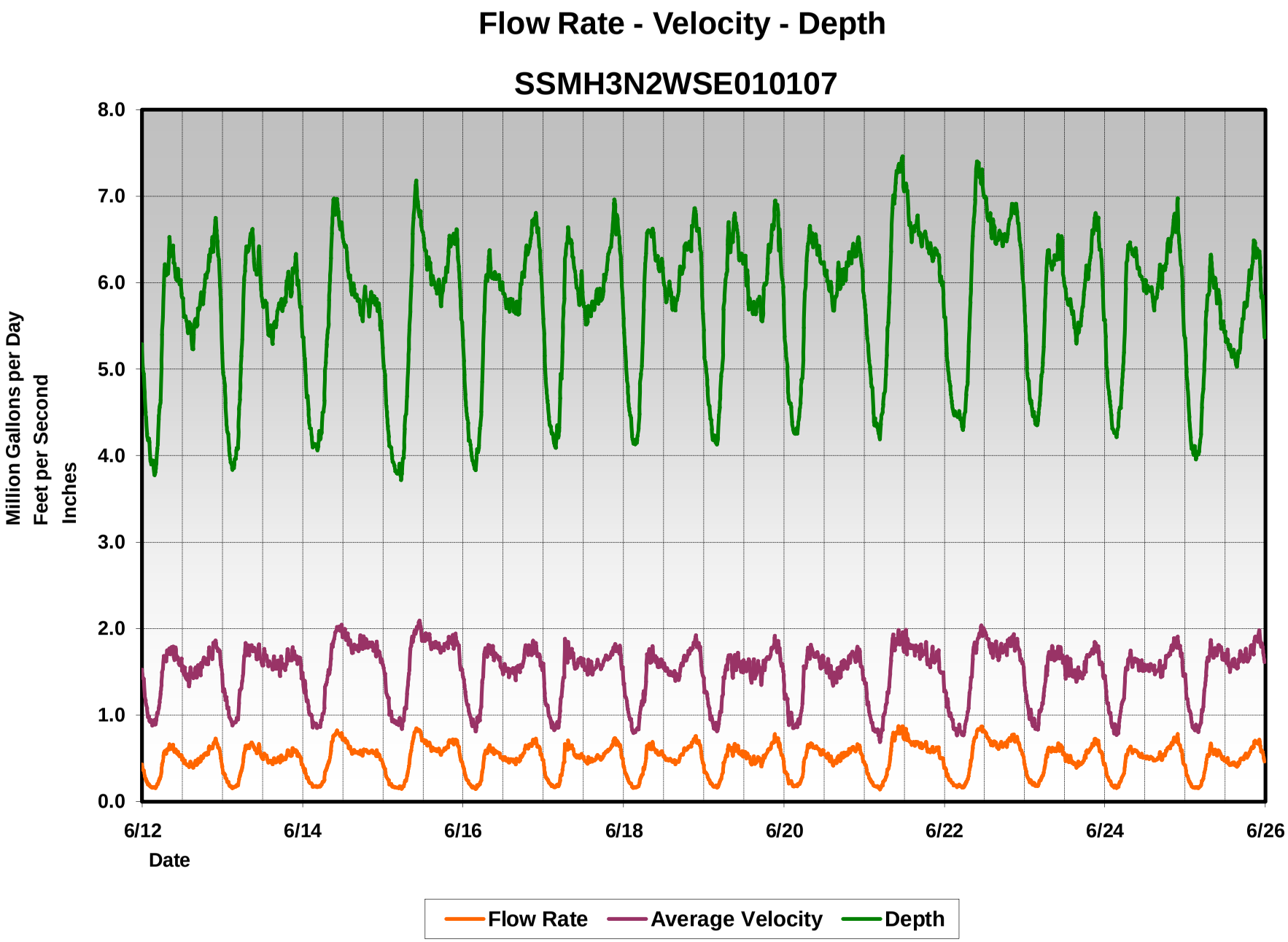
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	5.73
Maximum	7.46
Minimum	3.72
Max d/D	41.4%

Flow velocity	
	Feet per Second
Average	1.50
Maximum	2.09
Minimum	0.69

Flow Rate	
	Million Gallons per Day
Average	0.49
Maximum	0.87
Minimum	0.14
Peak Factor	1.78



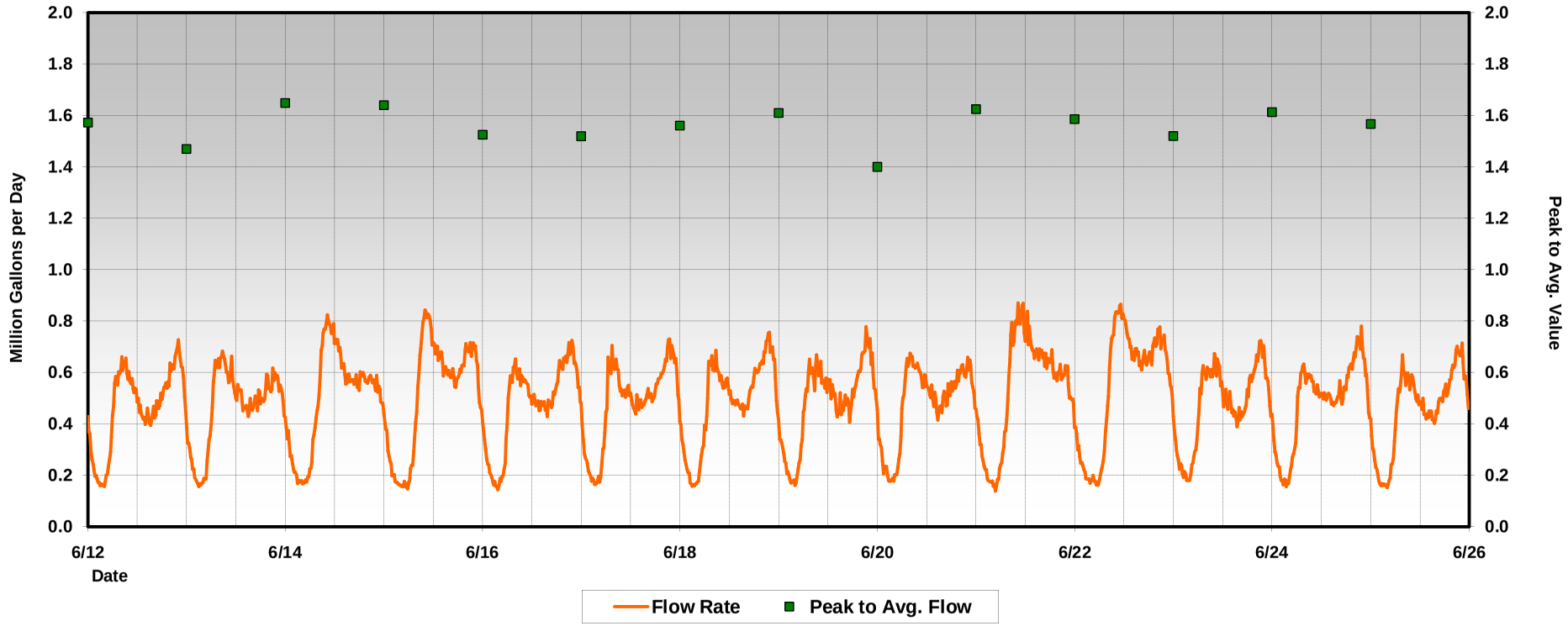

Flow Rate - Velocity - Depth
SSMH3N2WSE010107
Million Gallons per Day
Feet per Second
Inches
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Flow Rate
Average Velocity
Depth

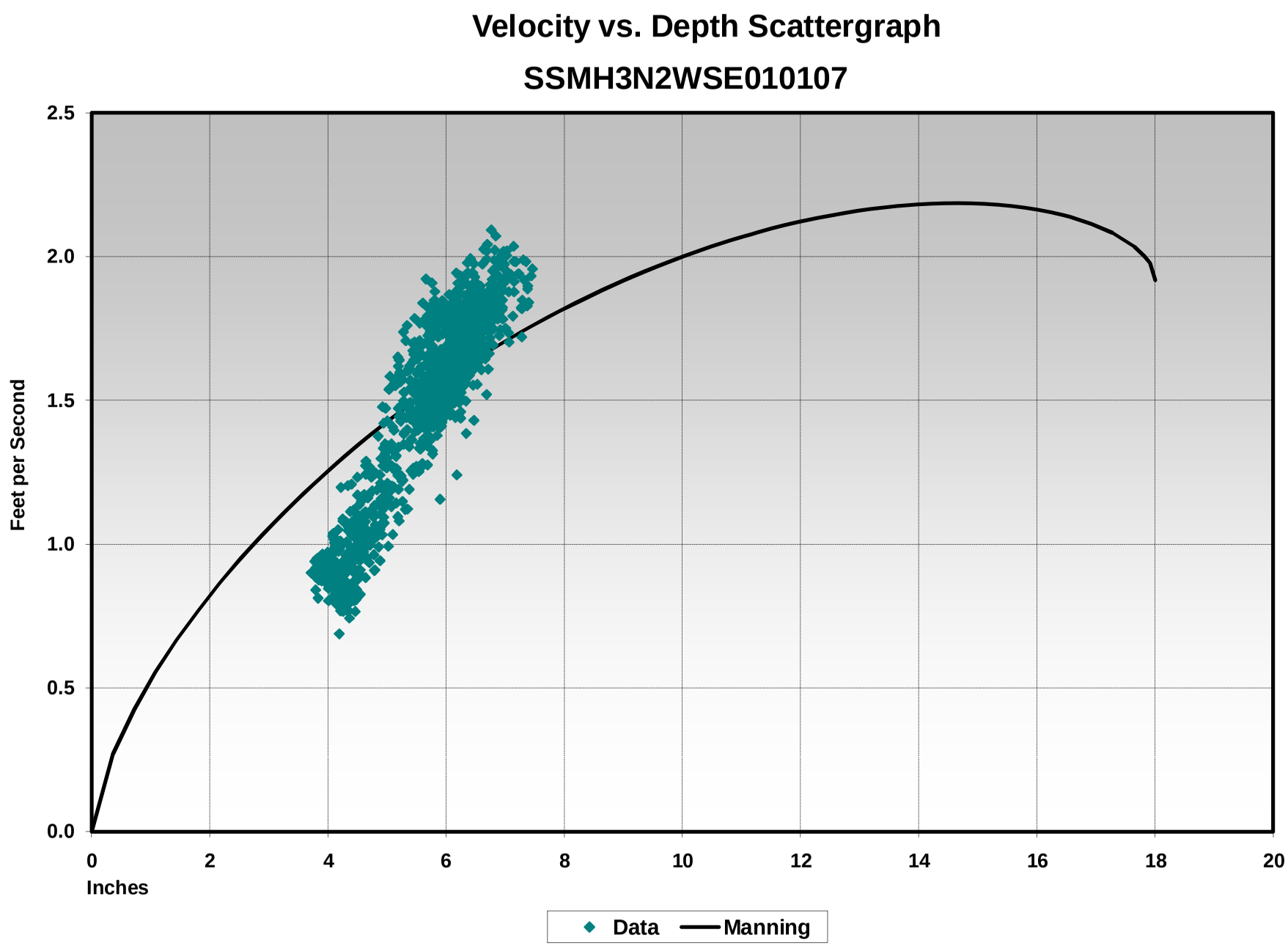
Peak to Average Flow Rate

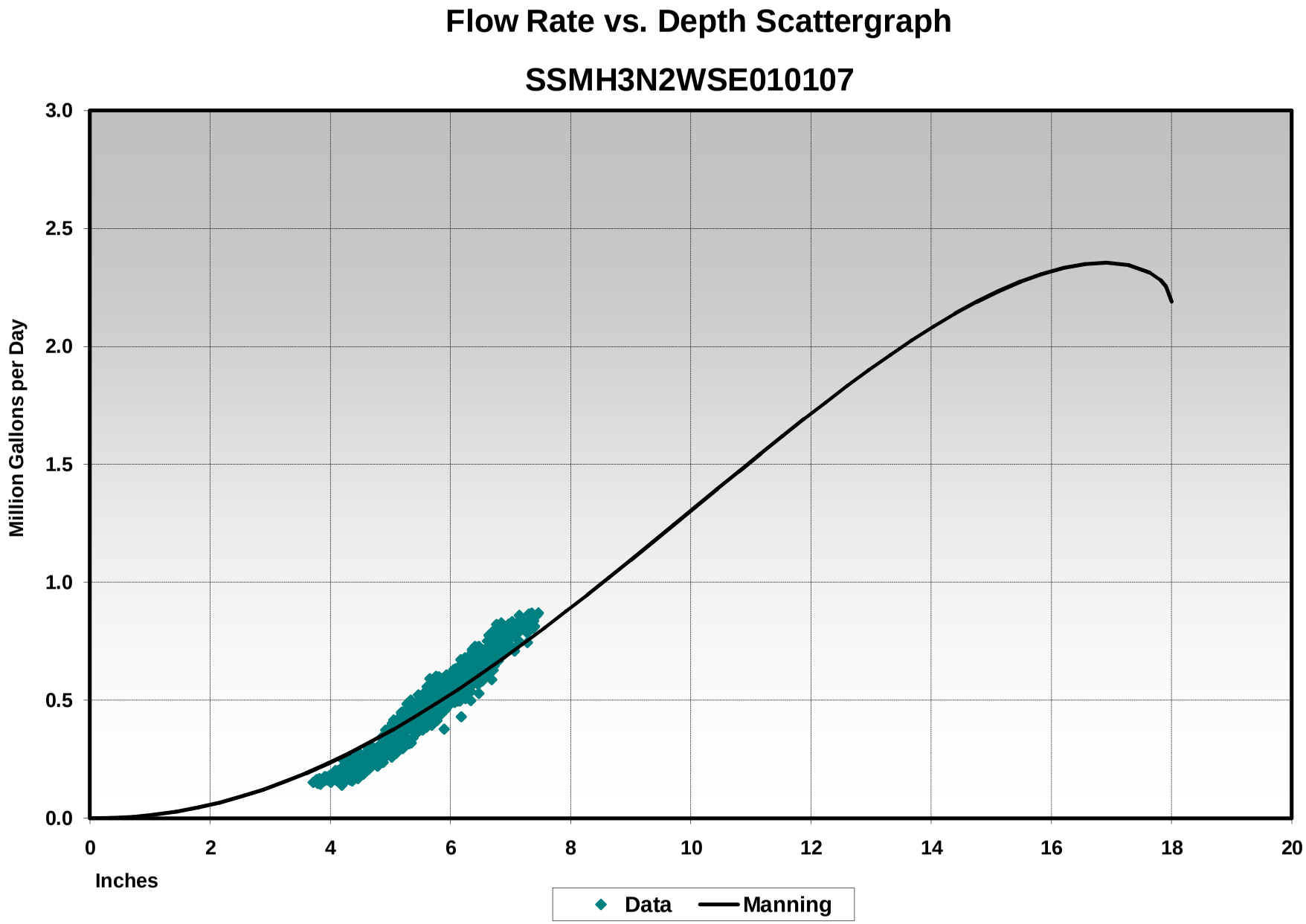
Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.57	1.47	1.65	1.64	1.52	1.52	1.56	1.61	1.40	1.62	1.59	1.52	1.61	1.57




Velocity vs. Depth Scattergraph
SSMH3N2WSE010107
Feet per Second
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH3N2WSE010107
Million Gallons per Day
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.36	0.34	0.38	0.40	0.36	0.37	0.36	0.36	0.36	0.42	0.36	0.36	0.36	0.34
1:00	0.23	0.24	0.28	0.27	0.24	0.25	0.25	0.27	0.25	0.29	0.27	0.25	0.25	0.23
2:00	0.18	0.18	0.21	0.19	0.18	0.19	0.19	0.20	0.21	0.22	0.21	0.21	0.18	0.17
3:00	0.16	0.16	0.17	0.17	0.16	0.17	0.16	0.17	0.18	0.18	0.18	0.19	0.17	0.16
4:00	0.18	0.18	0.17	0.16	0.18	0.19	0.18	0.19	0.20	0.16	0.18	0.22	0.21	0.17
5:00	0.28	0.31	0.19	0.16	0.25	0.30	0.29	0.29	0.28	0.19	0.17	0.30	0.30	0.27
6:00	0.51	0.50	0.26	0.20	0.51	0.55	0.43	0.49	0.51	0.27	0.21	0.48	0.50	0.46
7:00	0.58	0.63	0.40	0.32	0.60	0.63	0.64	0.59	0.63	0.41	0.33	0.60	0.61	0.58
8:00	0.63	0.65	0.56	0.56	0.60	0.63	0.63	0.59	0.65	0.69	0.57	0.60	0.58	0.58
9:00	0.61	0.64	0.75	0.76	0.58	0.56	0.60	0.63	0.63	0.76	0.76	0.59	0.58	0.57
10:00	0.58	0.59	0.80	0.83	0.57	0.51	0.56	0.60	0.60	0.81	0.83	0.64	0.53	0.56
11:00	0.53	0.58	0.77	0.78	0.52	0.53	0.56	0.55	0.57	0.83	0.84	0.59	0.53	0.49
12:00	0.48	0.52	0.72	0.70	0.50	0.49	0.50	0.55	0.54	0.77	0.79	0.51	0.51	0.48
13:00	0.43	0.50	0.67	0.67	0.47	0.47	0.49	0.53	0.50	0.72	0.72	0.49	0.51	0.43
14:00	0.43	0.46	0.60	0.63	0.47	0.48	0.47	0.44	0.47	0.68	0.67	0.45	0.49	0.44
15:00	0.41	0.46	0.58	0.61	0.46	0.48	0.46	0.47	0.46	0.67	0.67	0.42	0.48	0.41
16:00	0.45	0.48	0.57	0.59	0.48	0.52	0.47	0.49	0.51	0.66	0.64	0.44	0.52	0.47
17:00	0.48	0.50	0.56	0.56	0.51	0.50	0.54	0.45	0.52	0.65	0.65	0.45	0.51	0.50
18:00	0.52	0.49	0.58	0.60	0.59	0.55	0.60	0.53	0.55	0.65	0.66	0.55	0.58	0.53
19:00	0.55	0.55	0.58	0.64	0.63	0.59	0.62	0.59	0.57	0.58	0.71	0.59	0.63	0.57
20:00	0.62	0.53	0.58	0.69	0.66	0.63	0.66	0.66	0.61	0.60	0.75	0.65	0.69	0.64
21:00	0.66	0.59	0.57	0.70	0.70	0.70	0.74	0.73	0.60	0.60	0.72	0.70	0.73	0.68
22:00	0.67	0.56	0.55	0.67	0.65	0.68	0.68	0.68	0.64	0.57	0.65	0.63	0.65	0.65
23:00	0.54	0.49	0.50	0.49	0.54	0.56	0.54	0.54	0.52	0.49	0.55	0.50	0.50	0.53
Average	0.46	0.46	0.50	0.51	0.48	0.48	0.48	0.48	0.48	0.54	0.55	0.48	0.48	0.46
Median	0.49	0.50	0.56	0.59	0.51	0.51	0.51	0.52	0.53	0.60	0.65	0.50	0.52	0.49
Max Hr. Mean	0.67	0.65	0.80	0.83	0.70	0.70	0.74	0.73	0.65	0.83	0.84	0.70	0.73	0.68
Min Hr. Mean	0.16	0.16	0.17	0.16	0.16	0.17	0.16	0.17	0.18	0.16	0.17	0.19	0.17	0.16
Inst. Max	0.73	0.68	0.82	0.84	0.73	0.73	0.76	0.78	0.67	0.87	0.87	0.72	0.78	0.71
Inst. Min	0.16	0.16	0.17	0.15	0.14	0.17	0.16	0.16	0.18	0.14	0.16	0.18	0.16	0.15

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.40	1.32	1.38	1.52	1.36	1.34	1.28	1.31	1.27	1.35	1.23	1.25	1.30	1.29
1:00	1.09	1.14	1.17	1.23	1.11	1.07	1.06	1.15	1.04	1.07	1.07	1.04	1.05	1.05
2:00	0.94	0.96	1.01	1.00	0.94	0.92	0.89	0.95	0.94	0.90	0.93	0.94	0.85	0.87
3:00	0.90	0.90	0.89	0.93	0.88	0.86	0.81	0.87	0.87	0.82	0.82	0.87	0.84	0.85
4:00	0.97	0.94	0.88	0.90	0.94	0.90	0.87	0.89	0.91	0.77	0.83	0.96	0.92	0.87
5:00	1.20	1.26	0.90	0.91	1.12	1.20	1.10	1.13	1.13	0.85	0.79	1.14	1.16	1.12
6:00	1.60	1.57	1.11	1.01	1.65	1.62	1.26	1.49	1.57	1.08	0.90	1.44	1.50	1.51
7:00	1.69	1.76	1.43	1.29	1.74	1.69	1.70	1.63	1.71	1.33	1.17	1.69	1.68	1.72
8:00	1.74	1.76	1.62	1.75	1.74	1.71	1.67	1.58	1.77	1.78	1.58	1.72	1.62	1.72
9:00	1.71	1.75	1.87	1.91	1.71	1.61	1.65	1.62	1.68	1.81	1.81	1.68	1.64	1.75
10:00	1.70	1.70	1.99	2.02	1.67	1.59	1.60	1.64	1.67	1.86	1.92	1.75	1.55	1.79
11:00	1.61	1.68	2.02	1.99	1.57	1.62	1.60	1.55	1.61	1.90	1.98	1.66	1.57	1.67
12:00	1.52	1.64	1.95	1.90	1.54	1.57	1.54	1.58	1.56	1.84	1.93	1.57	1.54	1.69
13:00	1.44	1.64	1.89	1.90	1.50	1.55	1.50	1.61	1.52	1.82	1.83	1.55	1.55	1.56
14:00	1.44	1.60	1.81	1.83	1.50	1.53	1.48	1.43	1.45	1.79	1.75	1.47	1.55	1.61
15:00	1.45	1.57	1.77	1.82	1.48	1.53	1.46	1.51	1.45	1.75	1.79	1.45	1.50	1.56
16:00	1.51	1.57	1.77	1.80	1.54	1.60	1.43	1.56	1.51	1.73	1.70	1.48	1.53	1.67
17:00	1.53	1.59	1.81	1.75	1.55	1.56	1.57	1.48	1.55	1.74	1.76	1.45	1.51	1.66
18:00	1.62	1.56	1.82	1.79	1.70	1.65	1.66	1.60	1.60	1.72	1.76	1.61	1.65	1.68
19:00	1.62	1.66	1.83	1.83	1.74	1.66	1.70	1.66	1.60	1.60	1.85	1.69	1.71	1.70
20:00	1.74	1.64	1.82	1.86	1.76	1.70	1.77	1.76	1.71	1.68	1.88	1.74	1.81	1.78
21:00	1.79	1.71	1.78	1.88	1.81	1.78	1.87	1.82	1.66	1.65	1.80	1.80	1.86	1.88
22:00	1.79	1.64	1.74	1.82	1.71	1.76	1.79	1.77	1.73	1.62	1.73	1.67	1.77	1.88
23:00	1.66	1.58	1.66	1.55	1.59	1.64	1.59	1.58	1.51	1.49	1.60	1.52	1.56	1.73
Average	1.48	1.51	1.58	1.59	1.49	1.49	1.45	1.46	1.46	1.50	1.52	1.47	1.47	1.53
Median	1.56	1.60	1.77	1.78	1.56	1.58	1.53	1.55	1.55	1.64	1.73	1.54	1.55	1.64
Max Hr. Mean	1.79	1.76	2.02	2.02	1.81	1.78	1.87	1.82	1.77	1.90	1.98	1.80	1.86	1.88
Min Hr. Mean	0.90	0.90	0.88	0.90	0.88	0.86	0.81	0.87	0.87	0.77	0.79	0.87	0.84	0.85
Inst. Max	1.86	1.83	2.04	2.09	1.86	1.87	1.92	1.91	1.81	1.98	2.04	1.84	1.91	1.98
Inst. Min	0.88	0.88	0.85	0.84	0.81	0.83	0.79	0.81	0.85	0.69	0.77	0.83	0.77	0.80

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N2WSE010107

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	4.99	4.96	5.26	5.05	5.02	5.26	5.34	5.17	5.37	5.66	5.45	5.38	5.24	5.08
1:00	4.34	4.38	4.71	4.42	4.38	4.60	4.72	4.70	4.76	5.18	4.92	4.75	4.68	4.41
2:00	4.05	3.98	4.31	4.07	4.07	4.30	4.33	4.33	4.46	4.75	4.59	4.54	4.34	4.07
3:00	3.87	3.89	4.11	3.89	3.88	4.15	4.16	4.18	4.27	4.38	4.47	4.38	4.26	4.03
4:00	3.98	4.05	4.10	3.80	4.05	4.28	4.29	4.34	4.40	4.26	4.46	4.55	4.49	4.12
5:00	4.66	4.83	4.25	3.81	4.50	4.92	5.03	4.95	4.87	4.48	4.35	5.05	4.95	4.75
6:00	5.80	5.80	4.65	4.18	5.62	6.02	6.03	5.90	5.89	4.89	4.62	5.96	5.97	5.62
7:00	6.12	6.35	5.33	4.84	6.13	6.52	6.59	6.41	6.50	5.70	5.33	6.30	6.42	6.06
8:00	6.37	6.51	6.17	5.82	6.16	6.43	6.58	6.48	6.49	6.71	6.35	6.20	6.35	6.06
9:00	6.32	6.38	6.88	6.82	6.09	6.16	6.39	6.72	6.51	7.09	7.12	6.28	6.30	5.89
10:00	6.07	6.14	6.89	7.00	6.07	5.87	6.22	6.43	6.36	7.32	7.31	6.42	6.13	5.75
11:00	5.98	6.11	6.66	6.72	5.96	5.92	6.21	6.30	6.23	7.34	7.16	6.29	6.01	5.49
12:00	5.72	5.76	6.47	6.46	5.85	5.68	5.92	6.20	6.14	7.09	6.95	5.88	5.97	5.36
13:00	5.53	5.62	6.26	6.25	5.76	5.63	5.89	5.92	5.97	6.82	6.75	5.77	5.92	5.25
14:00	5.49	5.42	5.98	6.13	5.76	5.70	5.82	5.69	5.85	6.58	6.63	5.64	5.81	5.19
15:00	5.35	5.44	5.91	6.01	5.69	5.75	5.77	5.68	5.80	6.65	6.51	5.41	5.84	5.09
16:00	5.57	5.61	5.83	5.95	5.71	5.86	5.92	5.78	6.03	6.62	6.54	5.50	6.10	5.29
17:00	5.78	5.77	5.69	5.84	5.98	5.84	6.14	5.63	6.03	6.50	6.49	5.73	6.09	5.59
18:00	5.86	5.75	5.79	6.00	6.17	6.03	6.37	5.97	6.13	6.53	6.52	6.10	6.25	5.76
19:00	6.10	5.99	5.77	6.23	6.38	6.28	6.41	6.30	6.26	6.40	6.68	6.19	6.45	6.06
20:00	6.33	5.91	5.77	6.49	6.56	6.49	6.52	6.56	6.33	6.32	6.87	6.55	6.64	6.35
21:00	6.49	6.16	5.80	6.49	6.72	6.79	6.80	6.86	6.33	6.37	6.86	6.73	6.77	6.37
22:00	6.54	6.12	5.75	6.43	6.60	6.65	6.58	6.67	6.45	6.23	6.58	6.51	6.43	6.17
23:00	5.91	5.72	5.54	5.73	6.10	6.12	6.07	6.13	6.14	5.97	6.12	5.93	5.79	5.66
Average	5.55	5.53	5.58	5.60	5.63	5.72	5.84	5.80	5.82	6.08	6.07	5.75	5.80	5.39
Median	5.77	5.75	5.77	5.99	5.88	5.83	6.11	5.98	6.09	6.39	6.50	5.86	6.03	5.47
Max Hr. Mean	6.54	6.51	6.89	7.00	6.72	6.79	6.80	6.86	6.51	7.34	7.31	6.73	6.77	6.37
Min Hr. Mean	3.87	3.89	4.10	3.80	3.88	4.15	4.16	4.18	4.27	4.26	4.35	4.38	4.26	4.03
Inst. Max	6.75	6.62	6.97	7.18	6.81	6.96	6.86	6.95	6.66	7.46	7.40	6.81	6.98	6.49
Inst. Min	3.78	3.84	4.06	3.72	3.83	4.09	4.13	4.13	4.25	4.19	4.30	4.35	4.21	3.96

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name: Site 15
Address: Waddell Road 1/4 mile off Hwy 303
MH ID# SSMH3N2WSE120003

Date: 6/10/2008
GPS: 33.372801N -112.250286W

Overview

Street Level

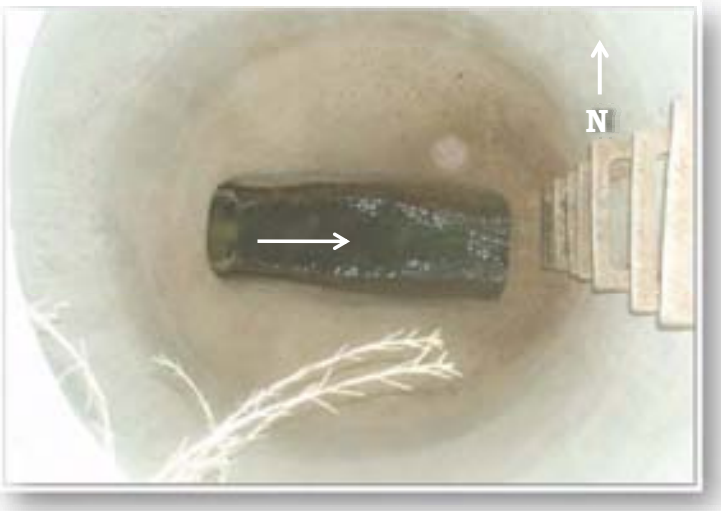
Meter Details

Meter Type	2150
Serial #	204L00432
Sensor Serial #	203B00998
Telemetry	None
Sample Rate	5 min

Pipe Details and Manhole Condition

Pipe Size (in)	Vert.	18"	Horiz.	18"
Laterals	0			
Pipe Material	PVC			
Surcharge Evidence	No			
Height Above Crown (in)	0			
Infiltration	No			
Silt	No			
Debris	No			
Grease	No			
Pests	No			

Down Manhole



Hydraulics:
Moderate to fast flow conditions

Comments:

Photos
MH #SSMH3N2WSE120003
Site #15

Site ID

Down Manhole

18” Influent

18” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

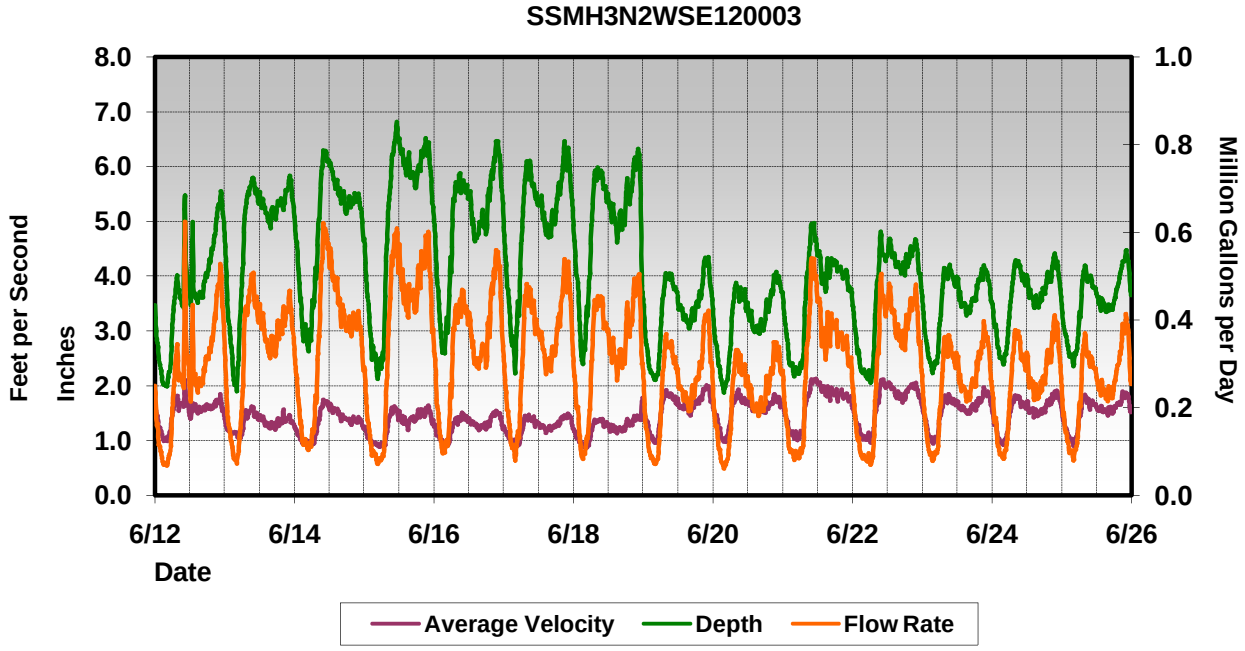
Site	**SSMH3N2WSE120003**	
Address	**Waddell Rd 1/4 mile from Hwy 303**	
Diameter	**18**	Inches
GPS	**33.372801N -112.250286W**	

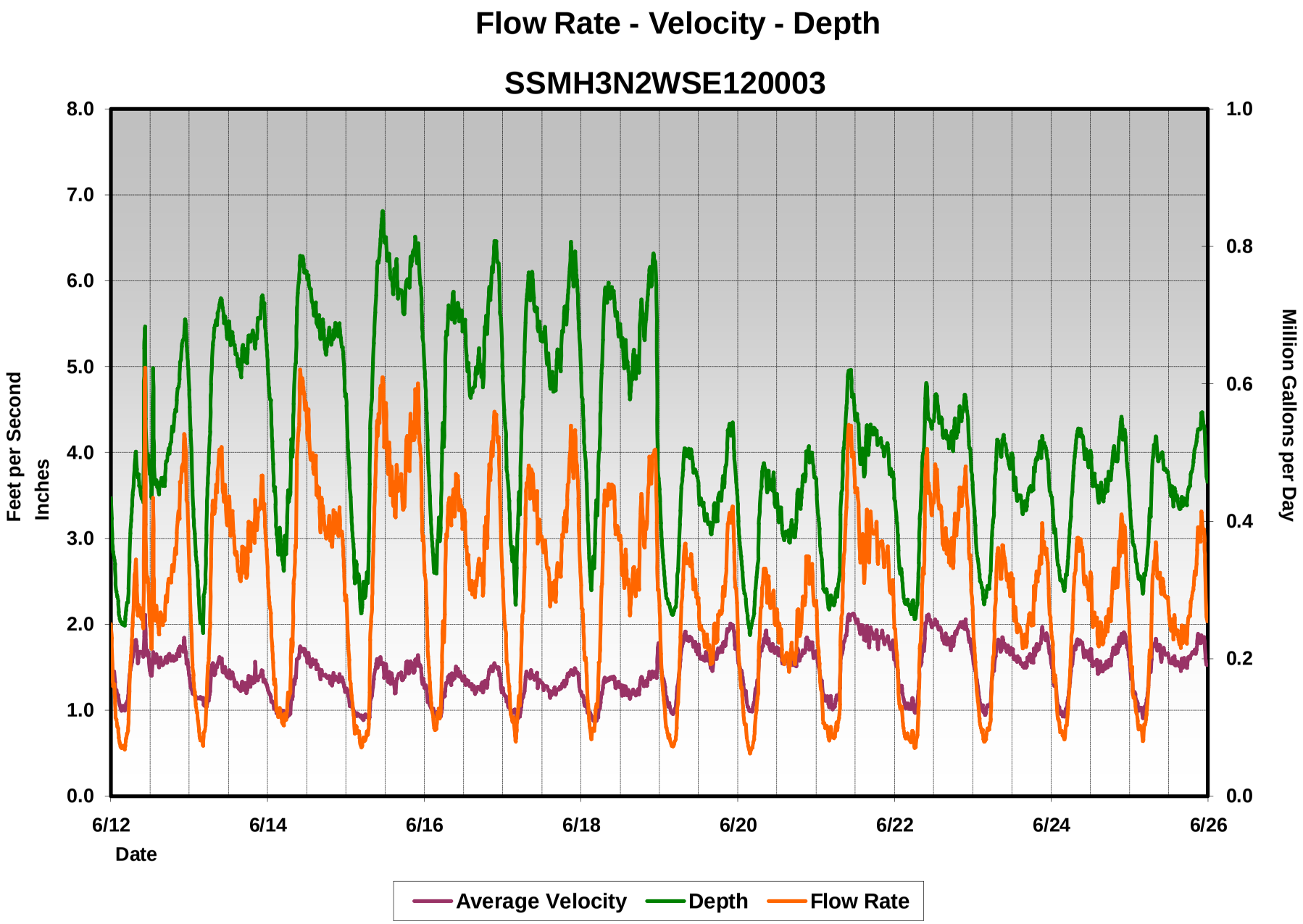
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	4.13
Maximum	6.81
Minimum	1.88
Max d/D	37.8%

Flow velocity	
	Feet per Second
Average	1.45
Maximum	2.12
Minimum	0.88

Flow Rate	
	Million Gallons per Day
Average	0.30
Maximum	0.62
Minimum	0.06
Peak Factor	2.09



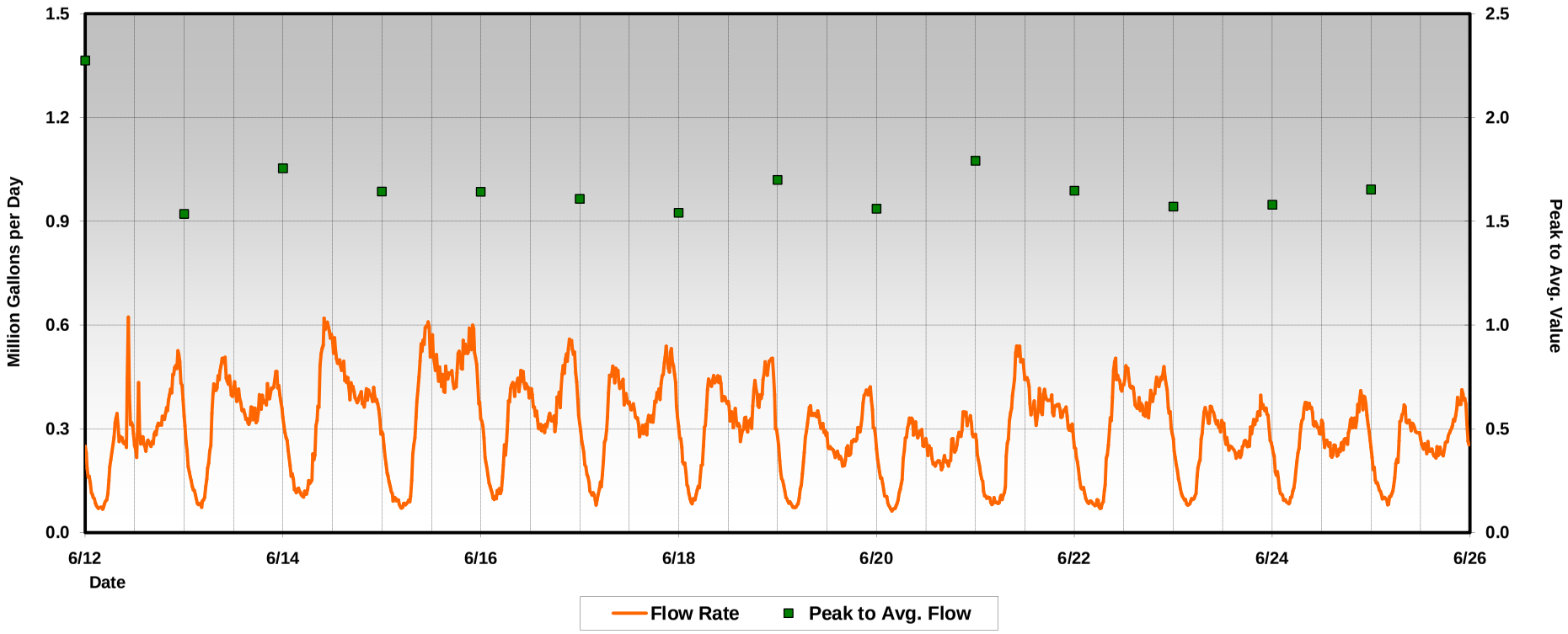

Flow Rate - Velocity - Depth
SSMH3N2WSE120003
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Feet per Second
Inches
1.0
0.8
0.6
0.4
0.2
0.0
Million Gallons per Day
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

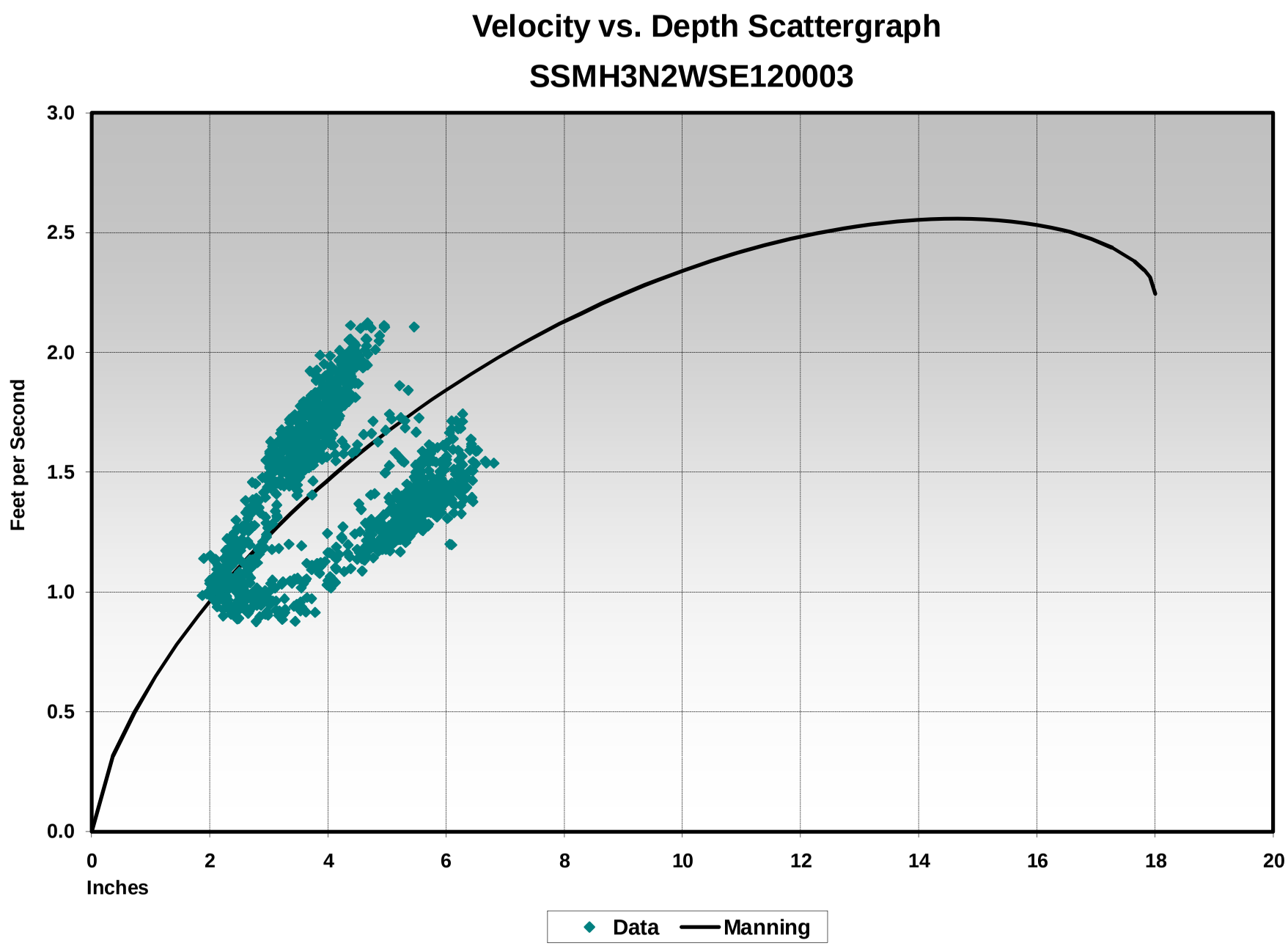
Peak to Average Flow Rate

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

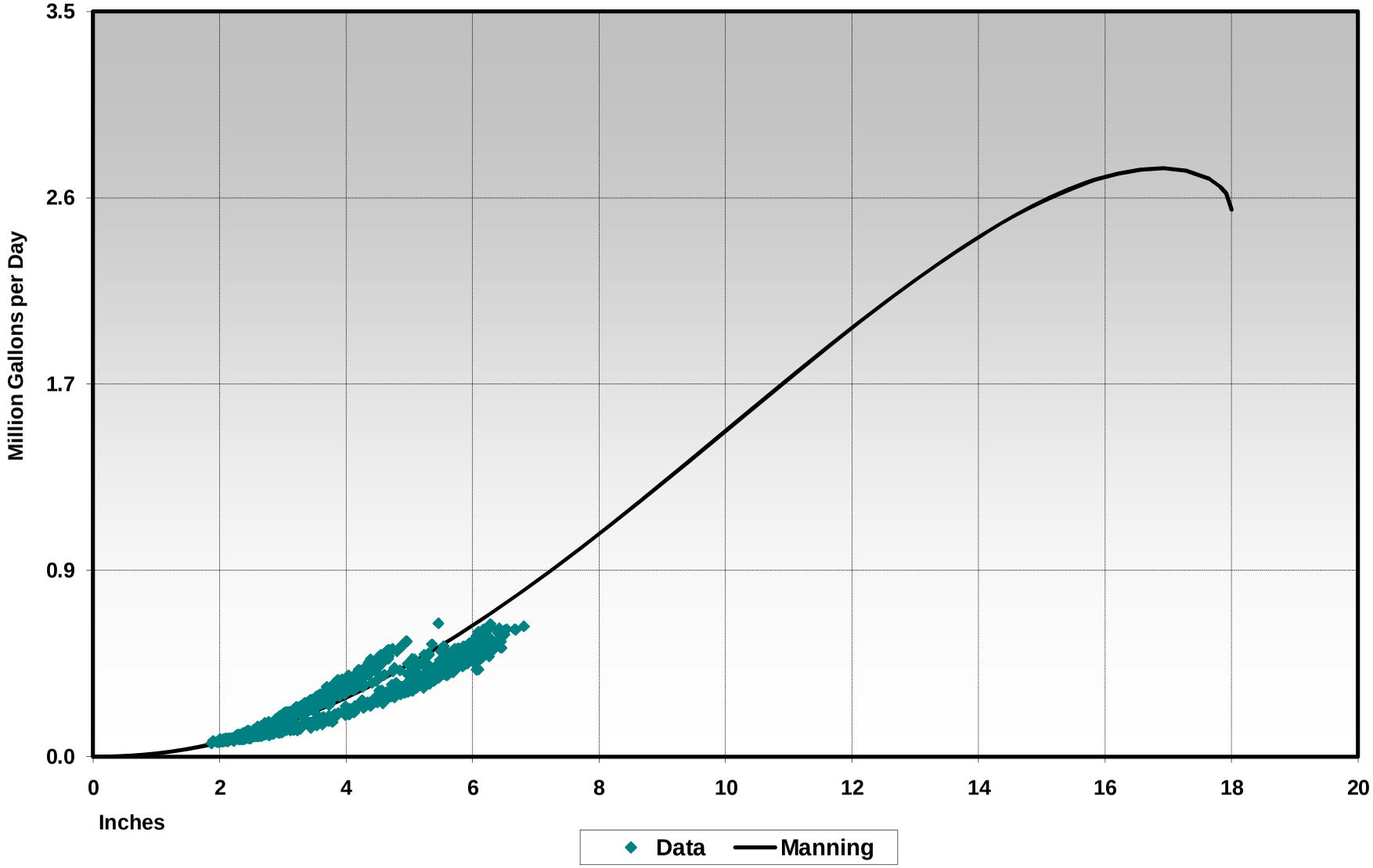
Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	2.27	1.54	1.75	1.64	1.64	1.61	1.54	1.70	1.56	1.79	1.65	1.57	1.58	1.65




Velocity vs. Depth Scattergraph
SSMH3N2WSE120003
Feet per Second
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0
2
4
6
8
10
12
14
16
18
20
Inches
Data
Manning

Flow Rate vs. Depth Scattergraph

SSMH3N2WSE120003



Flow Rate - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.21	0.29	0.30	0.26	0.31	0.28	0.27	0.23	0.21	0.25	0.23	0.23	0.22	0.21
1:00	0.13	0.17	0.23	0.17	0.19	0.20	0.19	0.14	0.14	0.17	0.15	0.15	0.16	0.14
2:00	0.09	0.12	0.15	0.11	0.13	0.14	0.12	0.09	0.10	0.11	0.12	0.10	0.11	0.11
3:00	0.07	0.09	0.12	0.10	0.10	0.11	0.09	0.08	0.07	0.10	0.09	0.08	0.09	0.10
4:00	0.07	0.09	0.11	0.08	0.12	0.10	0.12	0.08	0.07	0.09	0.09	0.09	0.09	0.09
5:00	0.11	0.14	0.11	0.08	0.18	0.16	0.17	0.11	0.10	0.09	0.09	0.12	0.14	0.13
6:00	0.22	0.26	0.14	0.09	0.30	0.29	0.30	0.22	0.19	0.10	0.08	0.22	0.24	0.22
7:00	0.32	0.41	0.20	0.18	0.41	0.44	0.43	0.33	0.29	0.18	0.14	0.33	0.33	0.33
8:00	0.28	0.45	0.34	0.35	0.42	0.46	0.44	0.35	0.33	0.33	0.28	0.33	0.37	0.34
9:00	0.26	0.50	0.52	0.50	0.44	0.45	0.44	0.34	0.30	0.44	0.42	0.36	0.36	0.31
10:00	0.43	0.46	0.60	0.57	0.44	0.42	0.41	0.32	0.28	0.53	0.46	0.32	0.31	0.31
11:00	0.31	0.42	0.58	0.58	0.42	0.38	0.38	0.30	0.26	0.49	0.42	0.31	0.29	0.29
12:00	0.26	0.40	0.54	0.52	0.40	0.36	0.35	0.26	0.25	0.44	0.46	0.29	0.29	0.25
13:00	0.31	0.39	0.50	0.47	0.34	0.35	0.34	0.24	0.22	0.37	0.44	0.25	0.26	0.25
14:00	0.25	0.35	0.48	0.45	0.30	0.30	0.31	0.23	0.20	0.35	0.40	0.24	0.23	0.24
15:00	0.26	0.32	0.44	0.44	0.30	0.30	0.28	0.21	0.20	0.37	0.37	0.22	0.24	0.22
16:00	0.26	0.34	0.41	0.46	0.33	0.31	0.31	0.21	0.21	0.38	0.36	0.23	0.24	0.24
17:00	0.30	0.33	0.40	0.44	0.33	0.33	0.32	0.23	0.20	0.39	0.36	0.26	0.26	0.23
18:00	0.32	0.37	0.39	0.48	0.34	0.38	0.41	0.27	0.25	0.38	0.38	0.27	0.28	0.27
19:00	0.34	0.38	0.38	0.50	0.41	0.41	0.38	0.28	0.25	0.36	0.40	0.31	0.32	0.30
20:00	0.39	0.39	0.40	0.53	0.49	0.48	0.42	0.33	0.29	0.36	0.44	0.34	0.33	0.34
21:00	0.45	0.42	0.39	0.56	0.53	0.49	0.48	0.40	0.35	0.35	0.46	0.37	0.38	0.38
22:00	0.50	0.45	0.39	0.55	0.53	0.51	0.50	0.40	0.32	0.32	0.41	0.35	0.38	0.40
23:00	0.43	0.39	0.34	0.42	0.41	0.40	0.36	0.31	0.29	0.30	0.32	0.29	0.30	0.30
Average	0.27	0.33	0.35	0.37	0.34	0.34	0.33	0.25	0.22	0.30	0.31	0.25	0.26	0.25
Median	0.27	0.37	0.38	0.45	0.35	0.35	0.34	0.25	0.24	0.34	0.36	0.26	0.27	0.25
Max Hr. Mean	0.50	0.50	0.60	0.58	0.53	0.51	0.50	0.40	0.35	0.53	0.46	0.37	0.38	0.40
Min Hr. Mean	0.07	0.09	0.11	0.08	0.10	0.10	0.09	0.08	0.07	0.09	0.08	0.08	0.09	0.09
Inst. Max	0.62	0.51	0.62	0.61	0.56	0.54	0.50	0.42	0.35	0.54	0.50	0.40	0.41	0.41
Inst. Min	0.07	0.07	0.10	0.07	0.10	0.08	0.08	0.07	0.06	0.08	0.07	0.08	0.08	0.08

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.53	1.32	1.22	1.22	1.27	1.20	1.17	1.58	1.54	1.60	1.56	1.53	1.47	1.47
1:00	1.31	1.19	1.11	1.07	1.09	1.10	1.07	1.33	1.38	1.39	1.32	1.32	1.25	1.20
2:00	1.13	1.14	1.02	1.00	1.02	1.01	0.98	1.11	1.17	1.16	1.20	1.06	1.02	1.07
3:00	1.02	1.14	0.99	0.94	0.95	0.99	0.91	1.02	1.02	1.12	1.06	0.99	0.95	1.02
4:00	1.03	1.10	0.97	0.93	0.93	0.92	0.90	0.98	1.01	1.07	1.05	1.02	0.97	0.97
5:00	1.21	1.06	0.96	0.90	1.03	0.97	0.97	1.19	1.18	1.04	1.08	1.13	1.20	1.16
6:00	1.54	1.23	0.94	0.93	1.22	1.18	1.18	1.56	1.48	1.14	1.00	1.48	1.54	1.48
7:00	1.77	1.48	1.10	1.01	1.37	1.40	1.35	1.82	1.73	1.40	1.28	1.73	1.74	1.76
8:00	1.64	1.49	1.35	1.30	1.36	1.42	1.35	1.85	1.86	1.75	1.63	1.73	1.80	1.77
9:00	1.67	1.58	1.60	1.53	1.43	1.38	1.37	1.83	1.78	1.94	1.89	1.79	1.77	1.68
10:00	1.85	1.48	1.71	1.58	1.42	1.37	1.32	1.77	1.73	2.09	2.08	1.71	1.65	1.69
11:00	1.64	1.43	1.68	1.50	1.38	1.33	1.30	1.71	1.70	2.11	2.00	1.69	1.63	1.65
12:00	1.45	1.41	1.62	1.44	1.35	1.29	1.24	1.66	1.70	2.04	2.01	1.65	1.62	1.57
13:00	1.59	1.39	1.55	1.36	1.33	1.27	1.24	1.60	1.61	1.95	1.97	1.60	1.55	1.59
14:00	1.57	1.30	1.56	1.36	1.28	1.20	1.21	1.63	1.57	1.92	1.89	1.57	1.47	1.54
15:00	1.56	1.24	1.49	1.28	1.23	1.21	1.18	1.57	1.56	1.90	1.83	1.52	1.51	1.51
16:00	1.56	1.29	1.42	1.42	1.25	1.23	1.21	1.54	1.57	1.88	1.80	1.54	1.51	1.55
17:00	1.61	1.25	1.41	1.38	1.28	1.25	1.21	1.64	1.55	1.88	1.79	1.61	1.55	1.52
18:00	1.61	1.31	1.38	1.48	1.27	1.31	1.34	1.70	1.63	1.86	1.84	1.61	1.59	1.62
19:00	1.60	1.34	1.34	1.49	1.35	1.33	1.31	1.75	1.63	1.81	1.94	1.70	1.69	1.66
20:00	1.66	1.40	1.39	1.49	1.48	1.42	1.33	1.82	1.69	1.85	1.99	1.75	1.75	1.71
21:00	1.70	1.38	1.36	1.54	1.51	1.43	1.41	1.95	1.82	1.80	2.00	1.89	1.83	1.82
22:00	1.74	1.42	1.38	1.57	1.49	1.46	1.42	1.96	1.74	1.78	1.91	1.86	1.86	1.83
23:00	1.57	1.33	1.29	1.39	1.33	1.33	1.56	1.79	1.66	1.73	1.75	1.72	1.71	1.62
Average	1.52	1.32	1.33	1.30	1.28	1.25	1.23	1.60	1.55	1.68	1.66	1.55	1.53	1.52
Median	1.58	1.32	1.37	1.37	1.30	1.27	1.26	1.66	1.62	1.81	1.82	1.62	1.57	1.58
Max Hr. Mean	1.85	1.58	1.71	1.58	1.51	1.46	1.56	1.96	1.86	2.11	2.08	1.89	1.86	1.83
Min Hr. Mean	1.02	1.06	0.94	0.90	0.93	0.92	0.90	0.98	1.01	1.04	1.00	0.99	0.95	0.97
Inst. Max	2.11	1.62	1.74	1.64	1.55	1.49	1.78	2.01	1.92	2.12	2.11	1.97	1.91	1.89
Inst. Min	0.99	1.04	0.92	0.89	0.91	0.90	0.88	0.96	0.98	1.01	0.97	0.95	0.93	0.91

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH3N2WSE120003

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	3.13	4.38	4.84	4.37	4.78	4.62	4.64	3.29	3.13	3.44	3.34	3.38	3.37	3.26
1:00	2.59	3.28	4.25	3.54	3.81	3.84	3.89	2.66	2.64	2.91	2.79	2.82	2.99	2.90
2:00	2.20	2.69	3.40	2.82	3.02	3.12	2.96	2.30	2.29	2.44	2.51	2.50	2.63	2.64
3:00	2.01	2.12	2.97	2.63	2.66	2.70	2.58	2.18	1.99	2.33	2.26	2.31	2.48	2.52
4:00	2.06	2.17	2.83	2.31	3.04	2.76	3.07	2.14	2.01	2.26	2.23	2.39	2.49	2.48
5:00	2.41	3.14	2.84	2.38	3.78	3.67	3.78	2.43	2.34	2.25	2.20	2.63	2.90	2.78
6:00	3.29	4.27	3.41	2.48	4.76	4.82	4.96	3.25	2.99	2.39	2.11	3.33	3.49	3.36
7:00	3.85	5.27	3.92	3.81	5.58	5.75	5.81	3.86	3.69	2.99	2.68	4.01	4.02	4.00
8:00	3.72	5.53	4.88	5.10	5.67	5.92	5.87	3.98	3.80	3.94	3.70	4.02	4.23	4.07
9:00	3.52	5.73	5.87	5.95	5.67	5.89	5.86	3.99	3.64	4.58	4.46	4.15	4.21	3.95
10:00	4.63	5.65	6.24	6.37	5.66	5.62	5.71	3.84	3.62	4.94	4.48	4.01	4.01	3.88
11:00	3.97	5.45	6.14	6.66	5.56	5.40	5.49	3.75	3.49	4.63	4.33	3.87	3.88	3.79
12:00	3.78	5.39	6.03	6.37	5.45	5.34	5.35	3.48	3.35	4.41	4.54	3.80	3.83	3.59
13:00	4.04	5.34	5.83	6.18	5.00	5.20	5.16	3.38	3.22	4.03	4.49	3.54	3.68	3.51
14:00	3.59	5.16	5.69	5.99	4.69	4.91	5.00	3.23	3.03	3.88	4.35	3.49	3.50	3.49
15:00	3.67	5.00	5.52	6.09	4.82	4.82	4.76	3.14	3.04	4.10	4.20	3.37	3.56	3.36
16:00	3.69	5.10	5.45	5.86	5.03	4.94	5.03	3.19	3.10	4.16	4.14	3.40	3.54	3.44
17:00	3.96	5.10	5.35	5.75	4.97	5.02	5.02	3.27	3.07	4.23	4.16	3.57	3.68	3.43
18:00	4.13	5.30	5.27	5.87	5.15	5.40	5.61	3.49	3.43	4.21	4.23	3.63	3.76	3.63
19:00	4.36	5.37	5.34	6.05	5.61	5.64	5.46	3.58	3.45	4.14	4.27	3.88	3.97	3.86
20:00	4.65	5.29	5.40	6.27	5.96	6.02	5.77	3.85	3.72	4.05	4.45	4.06	4.02	4.11
21:00	5.05	5.57	5.41	6.36	6.30	6.16	6.05	4.27	4.02	4.05	4.58	4.07	4.31	4.27
22:00	5.38	5.77	5.37	6.24	6.29	6.17	6.24	4.26	3.96	3.89	4.39	4.02	4.21	4.40
23:00	5.23	5.47	5.00	5.56	5.62	5.51	4.72	3.76	3.79	3.75	3.91	3.69	3.81	3.93
Average	3.70	4.73	4.88	5.04	4.95	4.97	4.95	3.36	3.20	3.67	3.70	3.50	3.61	3.53
Median	3.71	5.25	5.32	5.87	5.17	5.23	5.23	3.44	3.34	3.97	4.16	3.58	3.72	3.58
Max Hr. Mean	5.38	5.77	6.24	6.66	6.30	6.17	6.24	4.27	4.02	4.94	4.58	4.15	4.31	4.40
Min Hr. Mean	2.01	2.12	2.83	2.31	2.66	2.70	2.58	2.14	1.99	2.25	2.11	2.31	2.48	2.48
Inst. Max	5.55	5.83	6.29	6.81	6.46	6.45	6.32	4.35	4.07	4.96	4.81	4.20	4.41	4.47
Inst. Min	1.99	1.90	2.63	2.13	2.59	2.23	2.40	2.11	1.88	2.17	2.06	2.23	2.39	2.36

All Values in Inches

FLOW SERVICES GROUP

Location Information Summary

City of Surprise, AZ Flow Monitoring Study 2008

Site Name:	**Site 16**	**Date:**	**6/9/2008**
Address:	**163rd Avenue near Desert Oasis**	**GPS:**	**33.430391N -112.244448W**
MH ID#	**SSMH4N2WSE010020**		

Overview

Street Level

Meter Details

Meter Type	**2150**
Serial #	**202C00856**
Sensor Serial #	**204K02274**
Telemetry	**None**
Sample Rate	**5 min**

Pipe Details and Manhole Condition

Pipe Size (in)	**Vert.**	**24"**	**Horiz.**	**24"**
Laterals	**0**			
Pipe Material	**PVC**			
Surcharge Evidence	**No**			
Height Above Crown (in)	**0**			
Infiltration	**No**			
Silt	**No**			
Debris	**No**			
Grease	**No**			
Pests	**No**			

Down Manhole

Hydraulics:
Low flow conditions.

Comments:
Good monitoring site

Photos
MH #SSMH4N2WSE010020
Site #16

Site ID

Down Manhole

24” Influent

24” Effluent

Manhole Cover Top

Manhole Cover Bottom

Location Summary

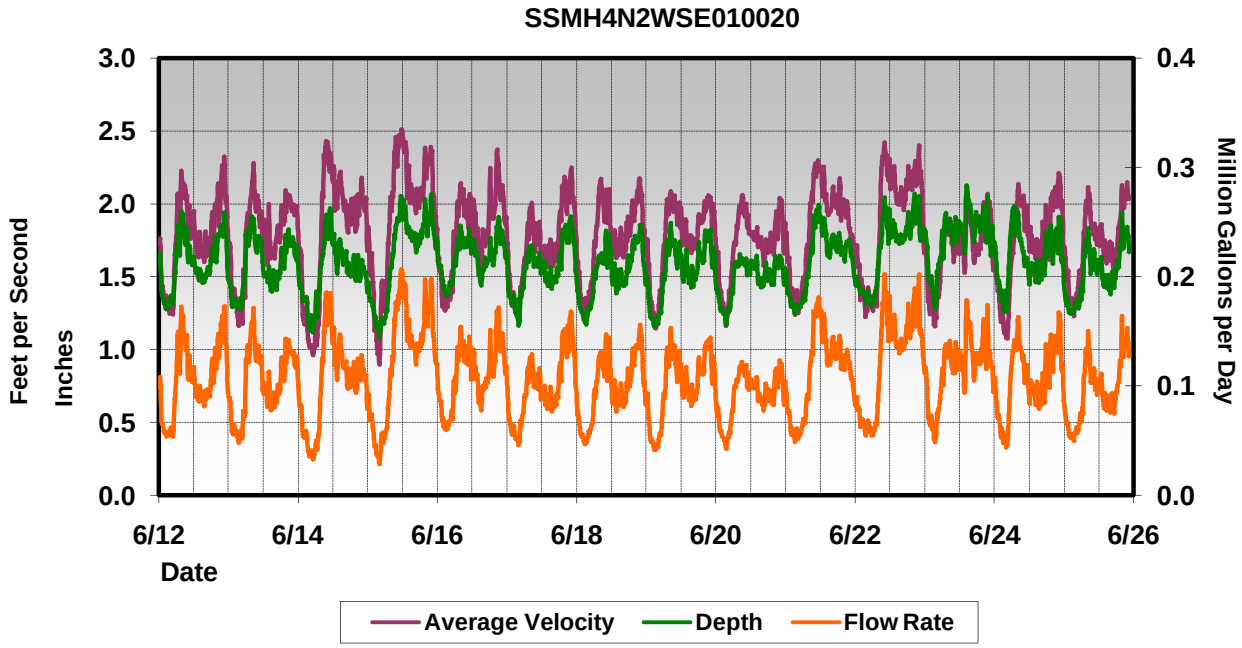
Site	**SSMH4N2WSE010020**	
Address	**163rd Ave S of Desert Oasis Blvd**	
Diameter	**24**	Inches
GPS	**33.430391N -112.244448W**	

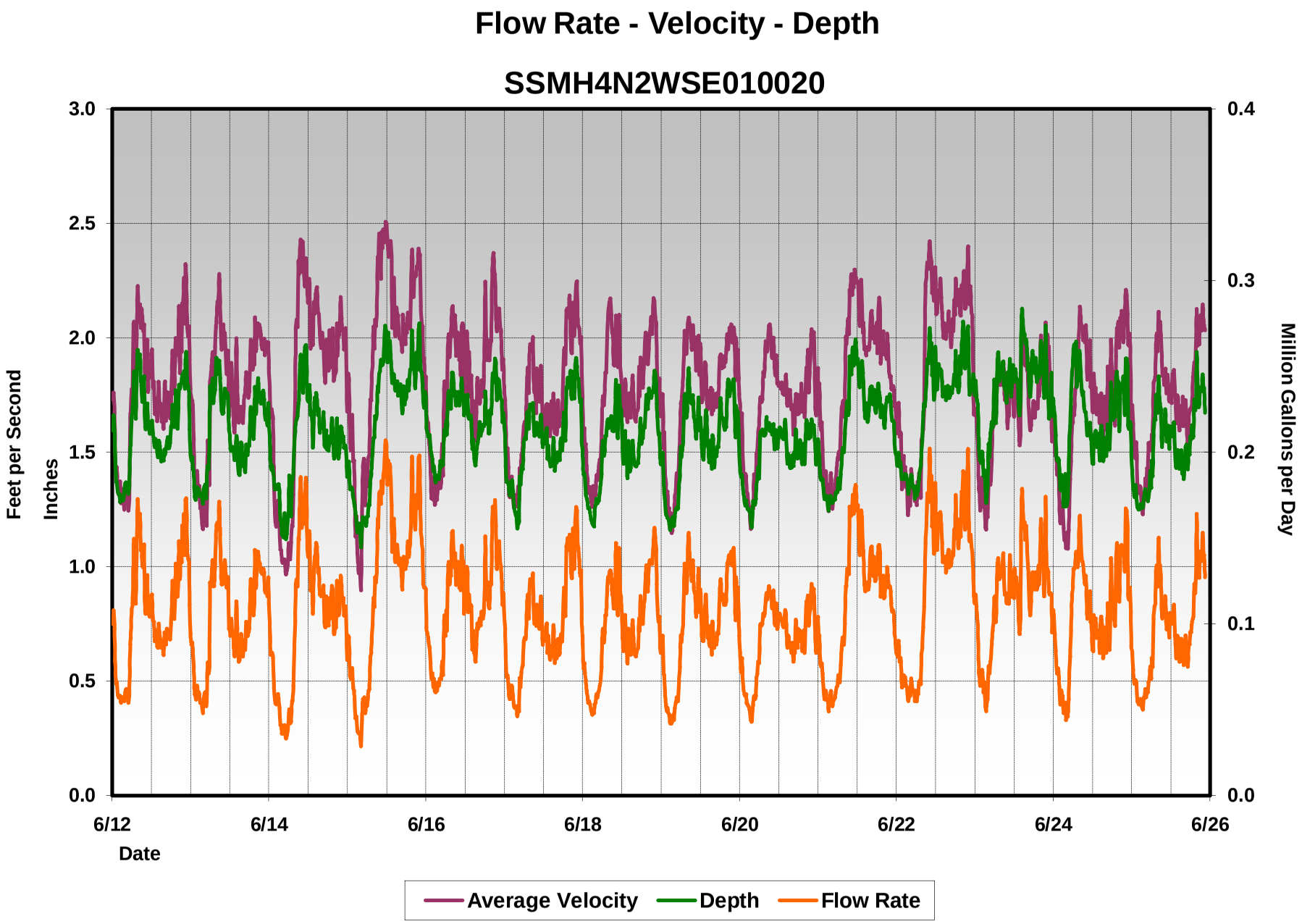
Report Date 6/12/2008 to 6/25/2008

Depth of Flow	
	Inches
Average	1.60
Maximum	2.12
Minimum	1.09
Max d/D	8.8%

Flow velocity	
	Feet per Second
Average	1.78
Maximum	2.51
Minimum	0.90

Flow Rate	
	Million Gallons per Day
Average	0.11
Maximum	0.21
Minimum	0.03
Peak Factor	1.94



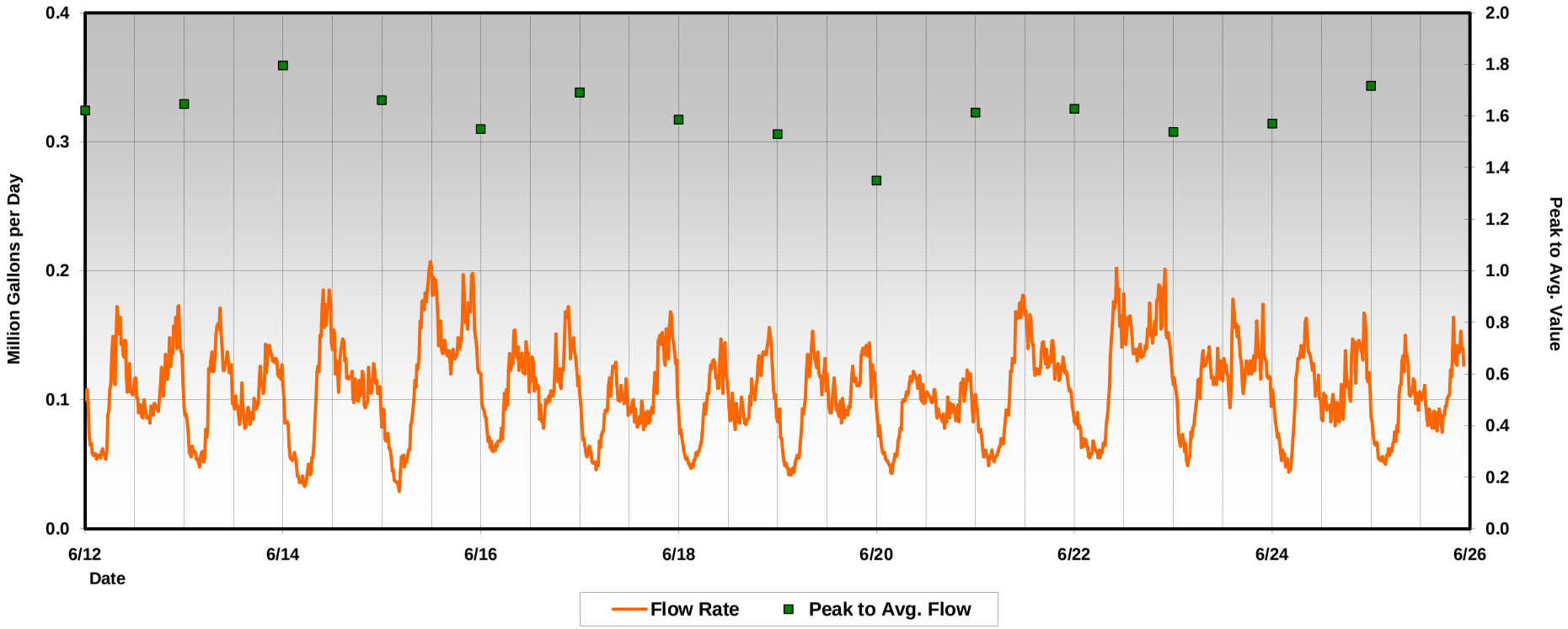

Flow Rate - Velocity - Depth
SSMH4N2WSE010020
Feet per Second
Inches
Million Gallons per Day
3.0
2.5
2.0
1.5
1.0
0.5
0.0
0.4
0.3
0.2
0.1
0.0
6/12
6/14
6/16
6/18
6/20
6/22
6/24
6/26
Date
Average Velocity
Depth
Flow Rate

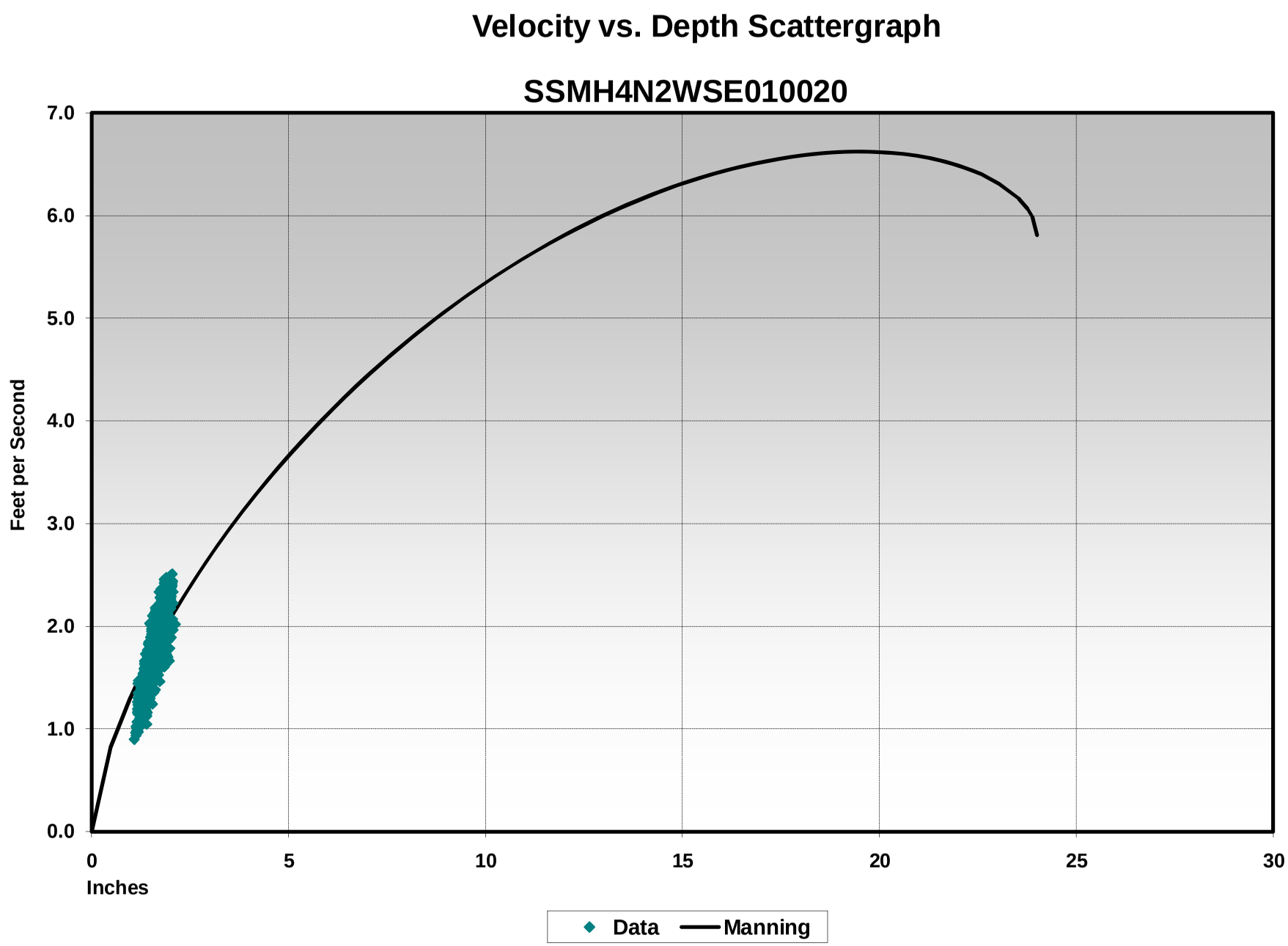
Peak to Average Flow Rate

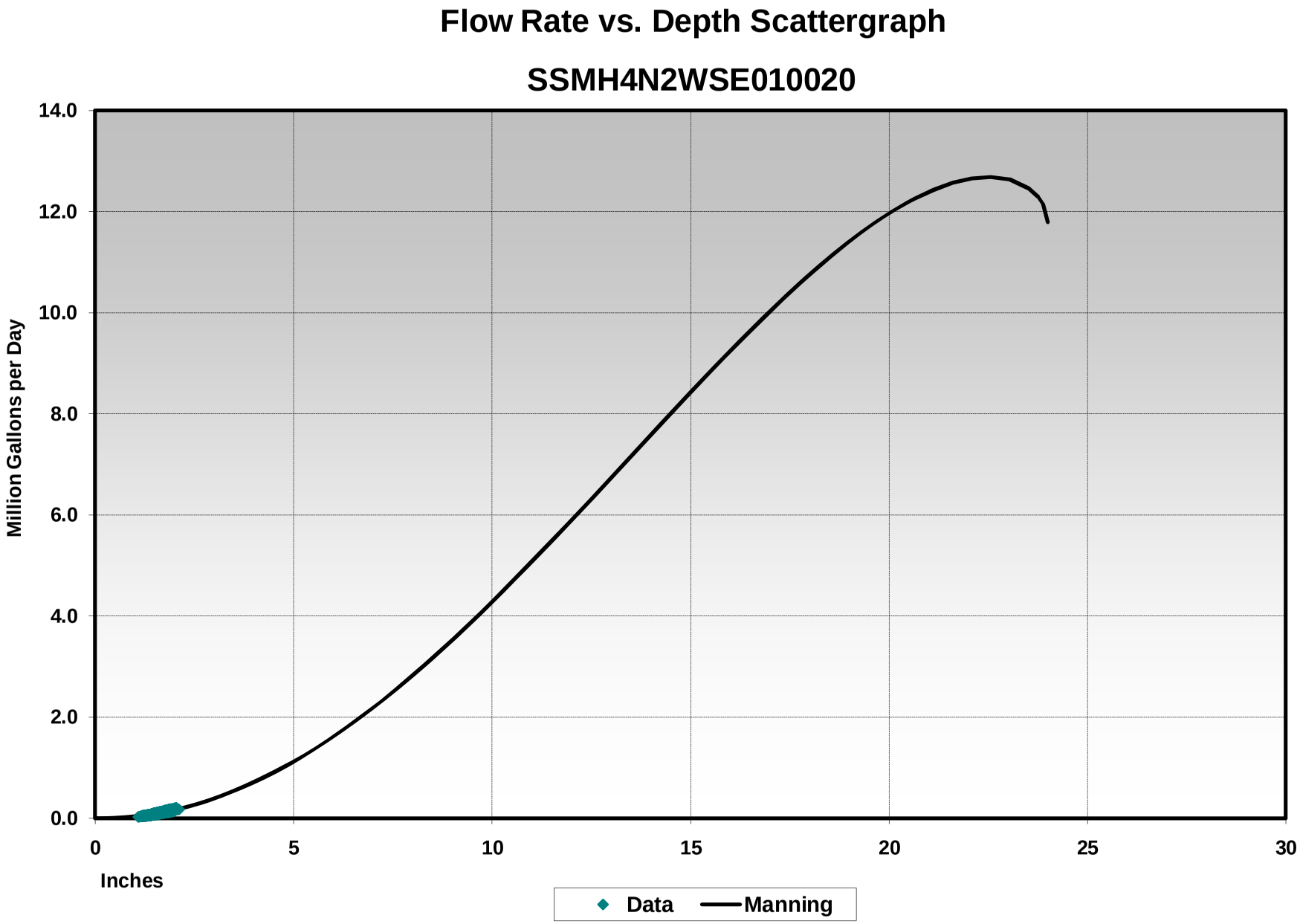
Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
Max Hr. Peak/Avg	1.62	1.65	1.80	1.66	1.55	1.69	1.59	1.53	1.35	1.61	1.63	1.54	1.57	1.73




Velocity vs. Depth Scattergraph
SSMH4N2WSE010020
Feet per Second
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning


Flow Rate vs. Depth Scattergraph
SSMH4N2WSE010020
Million Gallons per Day
14.0
12.0
10.0
8.0
6.0
4.0
2.0
0.0
0
5
10
15
20
25
30
Inches
Data
Manning

Flow Rate - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	0.10	0.09	0.09	0.08	0.10	0.09	0.08	0.08	0.08	0.09	0.08	0.11	0.10	0.08
1:00	0.07	0.06	0.07	0.07	0.08	0.06	0.06	0.06	0.06	0.07	0.07	0.08	0.07	0.06
2:00	0.06	0.06	0.06	0.05	0.07	0.06	0.05	0.05	0.05	0.06	0.07	0.07	0.06	0.05
3:00	0.06	0.05	0.05	0.04	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05
4:00	0.06	0.06	0.04	0.04	0.07	0.05	0.06	0.05	0.05	0.06	0.06	0.07	0.05	0.06
5:00	0.07	0.07	0.04	0.05	0.09	0.07	0.07	0.06	0.07	0.06	0.06	0.09	0.09	0.07
6:00	0.13	0.13	0.05	0.06	0.11	0.09	0.09	0.09	0.09	0.07	0.06	0.11	0.13	0.08
7:00	0.14	0.13	0.06	0.09	0.13	0.11	0.11	0.13	0.10	0.09	0.07	0.13	0.14	0.12
8:00	0.16	0.16	0.12	0.12	0.15	0.13	0.13	0.14	0.12	0.11	0.11	0.13	0.15	0.14
9:00	0.14	0.13	0.16	0.16	0.13	0.10	0.11	0.13	0.12	0.14	0.16	0.12	0.13	0.11
10:00	0.12	0.13	0.16	0.18	0.13	0.10	0.13	0.12	0.11	0.17	0.19	0.12	0.12	0.11
11:00	0.11	0.12	0.17	0.20	0.13	0.10	0.13	0.12	0.10	0.18	0.15	0.12	0.11	0.10
12:00	0.11	0.10	0.14	0.19	0.12	0.09	0.09	0.10	0.10	0.16	0.16	0.13	0.09	0.10
13:00	0.09	0.09	0.12	0.17	0.11	0.09	0.09	0.10	0.10	0.16	0.16	0.11	0.10	0.09
14:00	0.09	0.09	0.14	0.15	0.09	0.08	0.09	0.10	0.10	0.13	0.14	0.15	0.10	0.09
15:00	0.09	0.09	0.12	0.14	0.09	0.09	0.09	0.09	0.09	0.12	0.14	0.16	0.09	0.09
16:00	0.09	0.09	0.12	0.13	0.10	0.08	0.08	0.09	0.08	0.14	0.14	0.13	0.09	0.09
17:00	0.09	0.10	0.10	0.13	0.11	0.09	0.10	0.09	0.09	0.13	0.14	0.12	0.11	0.08
18:00	0.11	0.11	0.11	0.14	0.13	0.11	0.11	0.12	0.09	0.14	0.16	0.13	0.11	0.10
19:00	0.12	0.12	0.11	0.16	0.12	0.15	0.12	0.11	0.09	0.13	0.15	0.12	0.13	0.12
20:00	0.13	0.13	0.10	0.17	0.15	0.14	0.13	0.13	0.10	0.12	0.18	0.14	0.13	0.14
21:00	0.15	0.13	0.11	0.18	0.16	0.15	0.14	0.14	0.11	0.13	0.17	0.14	0.14	0.14
22:00	0.16	0.13	0.12	0.17	0.14	0.16	0.14	0.13	0.12	0.12	0.16	0.13	0.15	0.10
23:00	0.13	0.12	0.10	0.13	0.12	0.12	0.10	0.12	0.09	0.10	0.13	0.11	0.11	0.10
Average	0.11	0.10	0.10	0.12	0.11	0.10	0.10	0.10	0.09	0.11	0.12	0.12	0.11	0.09
Median	0.11	0.10	0.11	0.14	0.11	0.10	0.10	0.10	0.10	0.12	0.14	0.12	0.11	0.09
Max Hr. Mean	0.16	0.16	0.17	0.20	0.16	0.16	0.14	0.14	0.12	0.18	0.19	0.16	0.15	0.14
Min Hr. Mean	0.06	0.05	0.04	0.04	0.06	0.05	0.05	0.05	0.05	0.05	0.06	0.06	0.05	0.05
Inst. Max	0.17	0.17	0.19	0.21	0.17	0.17	0.16	0.15	0.12	0.18	0.20	0.18	0.17	0.16
Inst. Min	0.05	0.05	0.03	0.03	0.06	0.05	0.05	0.04	0.04	0.05	0.06	0.05	0.04	0.05

All Values in Million Gallons per Day

Average Velocity - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.73	1.73	1.75	1.72	1.69	1.66	1.60	1.67	1.66	1.75	1.63	1.65	1.57	1.63
1:00	1.40	1.40	1.49	1.57	1.45	1.39	1.41	1.40	1.43	1.53	1.52	1.36	1.42	1.47
2:00	1.32	1.36	1.22	1.29	1.33	1.35	1.32	1.25	1.33	1.34	1.41	1.33	1.24	1.34
3:00	1.30	1.22	1.14	1.01	1.33	1.29	1.31	1.19	1.20	1.31	1.30	1.23	1.17	1.27
4:00	1.31	1.28	1.02	1.12	1.37	1.33	1.37	1.31	1.31	1.31	1.34	1.33	1.12	1.36
5:00	1.47	1.38	0.99	1.41	1.59	1.48	1.48	1.44	1.49	1.36	1.33	1.52	1.42	1.50
6:00	1.92	1.86	1.07	1.45	1.76	1.63	1.72	1.76	1.70	1.48	1.32	1.71	1.69	1.62
7:00	1.97	1.93	1.30	1.79	1.99	1.83	1.95	1.98	1.82	1.68	1.41	1.80	1.89	1.91
8:00	2.10	2.16	1.98	2.03	2.07	1.97	2.14	2.06	1.96	1.84	1.74	1.83	2.08	2.04
9:00	2.08	2.04	2.35	2.31	1.99	1.76	1.95	2.01	2.03	2.08	2.28	1.76	2.01	1.91
10:00	1.92	2.00	2.34	2.39	1.92	1.80	2.00	1.95	1.95	2.23	2.37	1.69	1.94	1.81
11:00	1.82	1.83	2.27	2.46	1.97	1.75	1.97	1.94	1.84	2.26	2.19	1.76	1.86	1.78
12:00	1.87	1.78	2.15	2.41	1.92	1.65	1.71	1.82	1.79	2.18	2.18	1.75	1.73	1.79
13:00	1.68	1.67	2.06	2.30	1.81	1.67	1.73	1.83	1.77	2.15	2.21	1.65	1.73	1.75
14:00	1.73	1.78	2.18	2.12	1.68	1.64	1.72	1.74	1.76	1.97	2.06	1.86	1.70	1.68
15:00	1.65	1.68	2.06	2.09	1.67	1.69	1.77	1.73	1.75	1.95	2.02	1.92	1.67	1.69
16:00	1.75	1.71	1.98	1.98	1.74	1.63	1.66	1.73	1.64	2.06	2.04	1.77	1.69	1.66
17:00	1.71	1.80	1.88	2.04	1.80	1.66	1.81	1.75	1.70	2.01	2.07	1.64	1.76	1.61
18:00	1.83	1.89	1.93	2.06	2.05	1.90	1.86	1.90	1.72	2.07	2.18	1.69	1.79	1.73
19:00	1.90	1.93	1.95	2.18	1.95	2.11	1.97	1.90	1.74	1.98	2.14	1.74	1.90	1.91
20:00	1.99	2.01	1.90	2.26	2.22	2.03	1.97	1.98	1.79	1.98	2.23	1.89	2.05	2.02
21:00	2.06	2.02	2.02	2.32	2.17	2.10	2.10	2.03	1.87	1.94	2.20	1.89	2.06	2.09
22:00	2.22	1.96	2.08	2.22	2.08	2.16	2.06	1.96	2.01	1.80	2.25	1.94	2.15	1.54
23:00	2.00	1.97	1.94	1.91	1.92	1.97	1.76	1.92	1.75	1.74	1.92	1.70	1.94	1.54
Average	1.78	1.77	1.79	1.94	1.81	1.73	1.76	1.76	1.71	1.83	1.89	1.68	1.73	1.69
Median	1.79	1.83	1.96	2.05	1.84	1.71	1.78	1.82	1.75	1.94	2.06	1.73	1.77	1.72
Max Hr. Mean	2.22	2.16	2.35	2.46	2.22	2.16	2.14	2.06	2.03	2.26	2.37	1.94	2.15	2.09
Min Hr. Mean	1.30	1.22	0.99	1.01	1.33	1.29	1.31	1.19	1.20	1.31	1.30	1.23	1.12	1.27
Inst. Max	2.32	2.28	2.43	2.51	2.37	2.25	2.17	2.09	2.06	2.30	2.42	2.07	2.21	2.15
Inst. Min	1.24	1.17	0.97	0.90	1.27	1.26	1.26	1.15	1.17	1.24	1.23	1.16	1.08	1.23

All Values in Feet per Second

Depth - Tabular Output

Site ID SSMH4N2WSE010020

Start Date 6/12/2008
End Date 6/25/2008

Hour	Thu 6/12/2008	Fri 6/13/2008	Sat 6/14/2008	Sun 6/15/2008	Mon 6/16/2008	Tue 6/17/2008	Wed 6/18/2008	Thu 6/19/2008	Fri 6/20/2008	Sat 6/21/2008	Sun 6/22/2008	Mon 6/23/2008	Tue 6/24/2008	Wed 6/25/2008
0:00	1.62	1.47	1.51	1.41	1.63	1.50	1.42	1.45	1.43	1.49	1.47	1.76	1.67	1.40
1:00	1.38	1.33	1.39	1.33	1.54	1.35	1.29	1.27	1.31	1.37	1.43	1.54	1.47	1.31
2:00	1.30	1.33	1.35	1.24	1.43	1.35	1.23	1.19	1.26	1.30	1.39	1.45	1.38	1.26
3:00	1.31	1.30	1.27	1.17	1.39	1.24	1.20	1.19	1.21	1.28	1.36	1.34	1.35	1.27
4:00	1.35	1.33	1.16	1.15	1.43	1.24	1.28	1.23	1.27	1.29	1.38	1.49	1.31	1.32
5:00	1.43	1.45	1.16	1.19	1.50	1.41	1.34	1.31	1.37	1.31	1.34	1.63	1.68	1.33
6:00	1.74	1.79	1.28	1.24	1.62	1.56	1.51	1.52	1.53	1.35	1.33	1.75	1.93	1.44
7:00	1.78	1.78	1.43	1.43	1.72	1.65	1.60	1.71	1.58	1.47	1.44	1.87	1.86	1.70
8:00	1.88	1.88	1.63	1.61	1.81	1.71	1.64	1.78	1.61	1.60	1.66	1.88	1.87	1.75
9:00	1.77	1.74	1.81	1.77	1.74	1.61	1.60	1.72	1.61	1.75	1.83	1.77	1.72	1.59
10:00	1.67	1.73	1.82	1.88	1.73	1.59	1.70	1.62	1.57	1.90	1.97	1.84	1.62	1.62
11:00	1.60	1.71	1.90	1.99	1.75	1.60	1.74	1.66	1.54	1.95	1.81	1.82	1.58	1.57
12:00	1.60	1.53	1.74	1.96	1.71	1.56	1.51	1.57	1.60	1.85	1.85	1.84	1.51	1.59
13:00	1.53	1.50	1.61	1.89	1.66	1.52	1.49	1.57	1.57	1.86	1.87	1.75	1.55	1.51
14:00	1.52	1.49	1.74	1.81	1.55	1.45	1.46	1.54	1.54	1.71	1.77	1.98	1.55	1.48
15:00	1.48	1.49	1.64	1.77	1.48	1.51	1.50	1.50	1.46	1.68	1.76	2.00	1.52	1.47
16:00	1.51	1.45	1.63	1.74	1.58	1.48	1.44	1.49	1.46	1.77	1.76	1.87	1.54	1.47
17:00	1.54	1.52	1.54	1.74	1.61	1.52	1.54	1.53	1.52	1.71	1.79	1.85	1.62	1.48
18:00	1.64	1.63	1.54	1.77	1.67	1.62	1.57	1.67	1.54	1.76	1.84	1.88	1.68	1.58
19:00	1.67	1.66	1.57	1.89	1.63	1.79	1.68	1.62	1.49	1.69	1.83	1.84	1.78	1.68
20:00	1.72	1.75	1.52	1.87	1.76	1.79	1.75	1.75	1.57	1.66	2.02	1.91	1.73	1.78
21:00	1.82	1.74	1.52	1.93	1.84	1.82	1.76	1.77	1.59	1.73	1.94	1.88	1.79	1.79
22:00	1.86	1.73	1.58	1.93	1.80	1.86	1.80	1.72	1.63	1.70	1.85	1.75	1.84	1.31
23:00	1.73	1.66	1.51	1.75	1.69	1.69	1.57	1.65	1.51	1.58	1.81	1.74	1.62	1.31
Average	1.60	1.58	1.54	1.64	1.64	1.56	1.53	1.54	1.49	1.62	1.69	1.77	1.63	1.50
Median	1.60	1.56	1.55	1.76	1.65	1.56	1.54	1.57	1.53	1.67	1.77	1.81	1.62	1.52
Max Hr. Mean	1.88	1.88	1.90	1.99	1.84	1.86	1.80	1.78	1.63	1.95	2.02	2.00	1.93	1.79
Min Hr. Mean	1.30	1.30	1.16	1.15	1.39	1.24	1.20	1.19	1.21	1.28	1.33	1.34	1.31	1.26
Inst. Max	1.95	1.91	1.97	2.06	1.91	1.91	1.86	1.87	1.65	1.99	2.07	2.12	1.98	1.94
Inst. Min	1.28	1.28	1.12	1.09	1.37	1.17	1.18	1.16	1.17	1.25	1.30	1.28	1.26	1.25

All Values in Inches

D. Reclaimed Water System Model Development and Calibration

This appendix contains the technical memorandum summarizing the following tasks in its entirety:

- Task 6.2 – Flow Model

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City of Surprise, Arizona
Water Services Department • 12425 West Bell Road • Surprise, AZ 85374-9002

Integrated Water Master Plan

Reclaimed Water Technical Memorandum:

Task 6.2 – Flow Model

November 2008

Report Prepared By:

Malcolm Pirnie, Inc.

4646 East Van Buren Street
Suite 400
Phoenix AZ 85009

4957-007

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1. Introduction

1.1. Background Information

The City of Surprise (City) Water Services Department is responsible for the management of the City's drinking water, wastewater, reclaimed water, and recharge systems and the associated long range master planning documents.

The City is expecting to grow from a 2007 population of 104,895 to over 400,000 by 2030 (Maricopa Association of Governments, 2007). To prepare for this growth and additional growth as the City approaches build-out, the City prepared a *Water Resources Master Plan* and an *Infrastructure Master Plan* in June 2004. The Water Resources Master Plan was developed to ensure that the City's water supplies were adequate to meet the current and projected demands. The Infrastructure Master Plan addressed water, wastewater, reclaimed water, and groundwater recharge infrastructure. The master plans considered a municipal planning area (MPA) of 228 square miles that was broken up into five special planning areas (SPAs): SPA 1 through SPA 5. The master plans, however, did not consider the sixth, 71 square-mile expansion area in the north, SPA 6, that has since been added to the City's MPA.

The existing water resources and infrastructure master plans are in need of updating; they are now four years old, and considerable changes have been experienced in growth and development patterns, as well as the addition of SPA 6 to the City's MPA. In December 2007, the City retained Malcolm Pirnie, Inc., in association with Replenishment Services, LLC and ASU Decision Theater, to update the master plans into an *Integrated Water Master Plan*.

1.2. Project Purpose and Scope

The purpose of the *Integrated Water Master Plan* project is to provide a long-term guidance document for the orderly improvement and growth of the City's water supply portfolio and drinking water, wastewater, reclaimed water, and groundwater recharge infrastructure. Table 1-1 provides a summary of the scope of work technical tasks for each master plan component of the *Integrated Water Master Plan* project.

The purpose of the Water Resources Master Plan component is to identify the projected water demands as the City continues to grow and to develop a water resources strategy that will meet the demands in a cost-effective and sustainable manner. To prepare for the infrastructure master plan updates, the Water Resources Master Plan component also includes updates to projections of wastewater flows, reclaimed water availability, and

reclaimed water demands in an integrated fashion. Finally, the Water Resources Master Plan component includes a review and evaluation of water reuse options and reuse program alternatives as a critical element of the City's water resource portfolio.

The purpose of the Recharge Master Plan component is to support the Water Resources Master Plan by evaluating options and program alternatives to recharge reclaimed water supplies, and to develop a comprehensive plan and infrastructure improvements that allows the City to recharge reclaimed water in a legal, cost-effective, and sustainable manner.

The purpose of the Water Infrastructure, Wastewater, and Reclaimed Water Master Plan components is to enhance the existing plans where reasonable and to provide the City with comprehensive master plans that allow the City to manage its infrastructures in an effective and efficient manner and to provide for infrastructure expansions.

Table 1-1.
Integrated Water Master Plan Technical Scope of Work Tasks

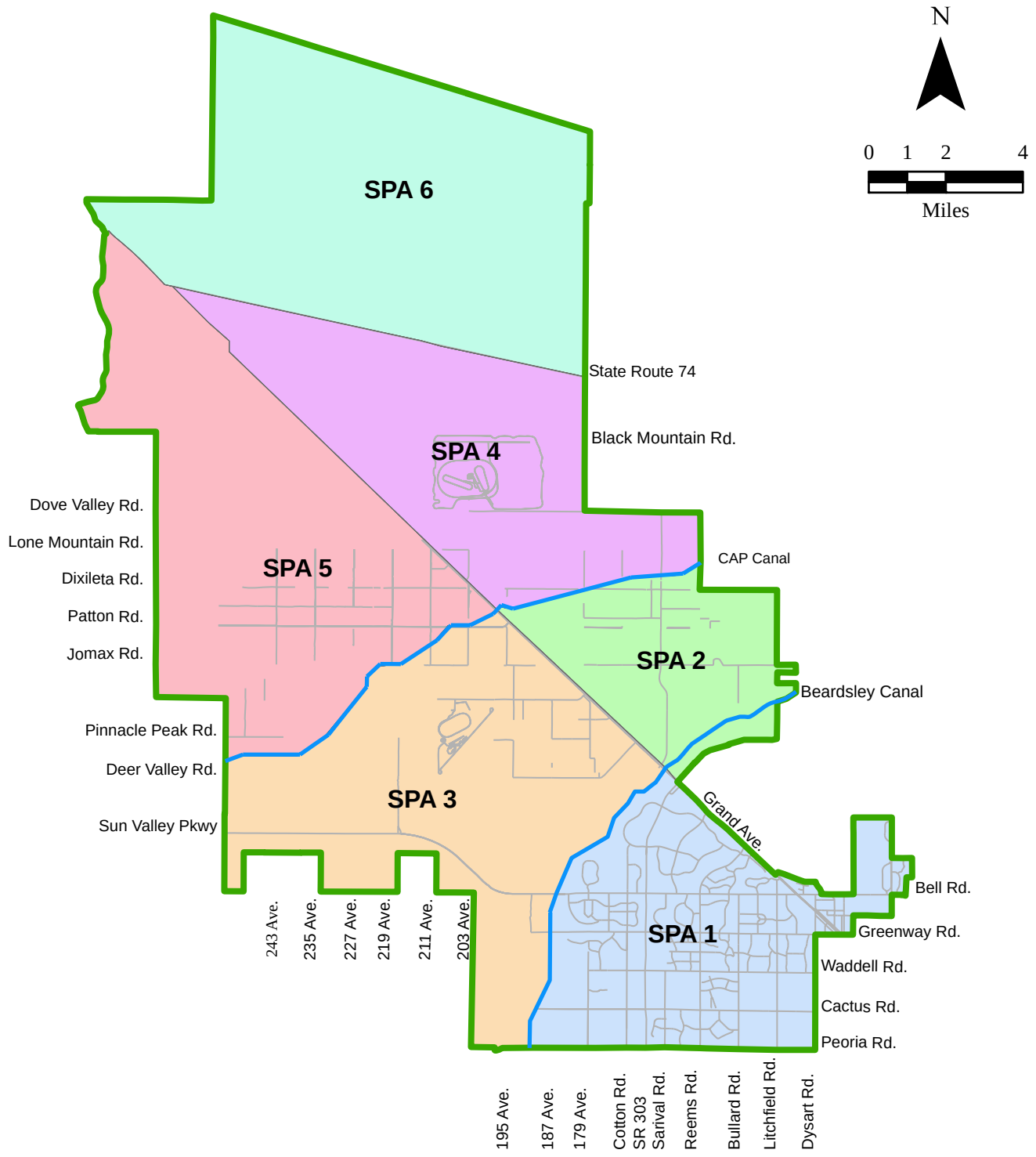
Water Resources Master Plan	**Drinking Water Infrastructure Master Plan**
2.1 Review of Regulations and Guidelines	4.1 Review of Regulations and Guidelines
2.2 Review of Background Information	4.2 Review of Background Information
2.3 Supplies	4.3 Fire Flow Testing
2.4 CAGRD Replenishment Obligations	4.4 Flow Model
2.5 Demand and Flow Factors	4.5 Evaluation of the Existing System
2.6 Demand Module	4.6 Improvements to the Existing System
2.7 Additional Water Supplies	4.7 Drinking Water Infrastructure Master Plan Report
2.8 Reclaimed Water Management	**Wastewater Master Plan**
2.9 Dual Water System Evaluation	5.1 Review of Regulations and Guidelines
2.10 Water Resource Model	5.2 Review of Background Information
2.11 Water Resource Scenarios	5.3 Wastewater Collection System Monitoring
2.12 Water Resource Management	5.4 Flow Model
2.13 Assured Water Supply Management	5.5 Evaluation of the Existing System
2.14 Water Resources Master Plan Report	5.6 Improvements to the Existing System
	5.7 Wastewater Master Plan Report
Recharge Master Plan	**Reclaimed Water Master Plan**
3.1 Regulations and Background Information	6.1 Review of Background Information
3.2 Recharge Methods and Evaluation	6.2 Flow Model
3.3 Recharge Improvements	6.3 Evaluation of the Existing System
3.4 Build-out of the Recharge System	6.4 Improvements to the Existing System
3.5 Recharge Master Plan Report	6.5 Reclaimed Water Master Plan Report

1.3. Purpose of Technical Memorandum

The purpose of this technical memorandum is to summarize the work conducted in Reclaimed Water Master Plan Task 6.2 (Flow Model). The technical memorandum includes the information available to build the existing reclaimed water model.

1.4. Study Area

The study area for this project, illustrated on Figure 1-1, includes all of the City's MPA. The MPA has been divided into six SPAs to maintain consistency with the City's previous master plan efforts and for convenience of wastewater and reclaimed water planning; i.e., the SPAs comprise logical drainage areas for existing, planned, and potential water reclamation facilities.



Legend

- Canals
- Streets
- Municipal Planning Area
- Special Planning Areas

MALCOLM PIRNIE

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Phoenix, AZ 85008

CITY OF SURPRISE, ARIZONA
INTEGRATED WATER MASTER PLAN

Study Area

November 2008 | **Figure 1-1**

m://4957007/GIS/Projects_MXD/Tech Memo 2/Figure 1_1_Study Area.mxd

2. Model Development

This section presents a brief summary of how the City's reclaimed water system model was developed. The City does not have an existing reclaimed water system model as the system that is currently built has not been utilized yet. As such, only a future system model can be developed that includes the infrastructure that has been constructed. Since the system has not been operated yet, there was be no information available to calibrate the model.

The reclaimed water system was modeled using personal computer based modeling software and related databases. The model served as a tool to aid in designing the system to support varying supply and demand conditions and to identify system modifications and expansions necessary to meet future demand.

2.1. Generic Model Description

The City's reclaimed water system pipelines, storage tanks, boosters, and valves were modeled using Bentley WaterCAD® V8 XM edition. The software uses an iterative procedure to determine the steady state system response to a given supply and demand scenario. The software is also capable of performing extended period simulations for known diurnal patterns of supply and demand and can simulate water quality fluctuations within the distribution systems. A steady state model was developed for the current master planning effort. The results obtained from such quantitative analysis are considered conservative for evaluating and planning for future improvements and system developments.

2.1.1. Transmission Pipelines

The City's existing reclaimed water system is represented by more than 90 pipes in its geographic information system (GIS) database. The existing reclaimed water distribution system consists of polyvinyl chloride (PVC) and ductile iron (DI) pipes, ranging in diameter from 2 inches through 30 inches. Most pipelines in the system follow existing streets and public rights-of-way.

Because this is a master planning effort, all existing pipes with diameters 8 inches and greater, and only future piping required to distribute the reclaimed water at a one square-mile grid were represented in the model. Table 2-1 provides the statistics on percentage of existing pipes to be represented in the model.

Table 2-1.
Summary of Existing Pipes Modeled

	Length (ft)			Volume (ft^3)		
Pipe Diameter (in)	**Total**	**In Model**	**% in Model**	**Total**	**In Model**	**% in Model**
2	69	-	0	2	-	0
8	464	464	100	162	162	100
12	5,473	5,473	100	4,298	4,298	100
16	14,164	14,164	100	19,777	19,777	100
24	5,143	5,143	100	16,157	16,157	100
30	2,273	2,273	100	11,158	11,158	100
Total	27,586	27,517	99.7	51,553	51,551	100

2.1.2. Model Nodes

Model nodes can serve a number of functions and contain vital information concerning supply, demand, and physical characteristics of certain facilities. Three types of nodes were used in the modeled system: boundary nodes, junction nodes and source nodes.

Tanks and reservoirs are classified as boundary nodes. The storage facilities in the system were represented as cylindrical tanks with known diameters, heights and base elevations. The initial tank levels represented the known hydraulic grade line (HGL).

Junction nodes occur at all pipeline endpoints that are not represented by a tank or reservoir. Each junction has specific information that identifies the node's elevation, demand, and demand type. Each node in the model was assigned an elevation that corresponded to the local surface elevation relative to the mean sea level, based on most recent United States Geological Survey (USGS) five-foot topographical data.

The existing South WRF and Desert Oasis WRF were represented as source nodes with fixed boundary conditions. Elevation information was assigned to the junctions based on most recent United States Geological Survey (USGS) five-foot topographical data. Future WRFs were added as additional source nodes.

Each pump in the system was modeled using a single design point pump curve. The point represented the design flow and head for the pump. The design point information was noted from the manufacturer's tag in the pumps during the field visit and was verified by the City.

2.1.3. Pumps

Pump information for booster stations at the WRFs were obtained during the site visit on May 1, 2008 and were verified by the City. Each pump in the system was modeled using

a single design point pump curve. The point represented the design flow and head for the pump. The design point information for each pump was developed from typical vendor pump design information. The elevation of the pumps were set the same as the base elevation of the tank associated with the pumps.

2.1.4. Valves

Pressure reducing valves (PRVs) may be located at various locations within the distribution system to prevent the downstream hydraulic grade from exceeding a preset value. The elevation, diameter, and pressure setting value for each PRV was assigned as system hydraulics dictated.

2.1.5. Water Demand Allocation

Reclaimed water demands were obtained from the Water Resource Demand Module developed as part of Water Resources Master Plan Tasks 2.5 (Demand Factors) and 2.6 (Demand Module). The nearest-node demand allocation method was used to allocate demands to the modeled junctions. This method used the spatial analysis capabilities of GIS to assign the water usage demand polygons from the Demand Module to the nearest demand node.

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3. Model Calibration

As indicated previously, the City did not have an existing reclaimed water model and the existing reclaimed water distribution system had not been operated as a distribution system yet. Portions of the system are currently used to convey reclaimed water to a farm. No information was available to calibrate the portions of the model representing the existing infrastructure.

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E. Drinking Water Infrastructure Alternatives

This appendix provides additional information on the development of the drinking water infrastructure alternatives.

E.1. Future System Demand Scenario

As described in the Water Resources component of the *Integrated Water Master Plan*, indoor and outdoor demands will be served with potable water, while landscape (large irrigation) demands will be served via the reclaimed water distribution system. The demand set used for all water system evaluations was the Mid-Population Scenario (i.e., population of approximately 700,000 at build-out) identified in the Water Resources component of the *Integrated Water Master Plan*. This scenario involved serving all private water company service areas within the City's MPA, with the exception of the Arizona American Water Company (AAWC) and City of El Mirage service areas. In this scenario, the City would control development densities to balance water demands with available supplies.

Table E-1 summarizes the preliminary build-out potable water demands obtained from the Demand Module and that were used for the purpose of the drinking water infrastructure evaluation. Because the alternative evaluations were preformed prior to the completion of the Water Resources component of the *Integrated Water Master Plan*, the demands used for the evaluation varied slightly from the demands used to phase the selected alternative in Section 7 of the Water Infrastructure component of the *Integrated Water Master Plan*. The preliminary and finalized demands varied by less than 2 percent.

Table E-1.
Build-out Drinking Water Demands Used for Infrastructure Alternatives

Special Planning Area	Indoor Demand (mgd)	Outdoor Demand (mgd)	Total Potable Water Demand (mgd)
SPA 1	5.8	3.1	8.8
SPA 2	8.9	4.8	13.7
SPA 3	19.4	10.3	29.7
SPA 4	12.2	6.9	19.1
SPA 5	15.4	8.2	23.7
SPA 6	10.7	5.6	16.3
TOTAL	**72.4**	**38.9**	**111.3**

All modeling of future scenarios was conducted for the build-out condition. As such, the comparisons presented in this memo represent infrastructure and costs at build-out. Based on comments received from the City, the selected alternative was remodeled prior to developing a phasing and implementation schedule for 2020 and build-out conditions.

E.2. System Performance and Design Criteria

Tables E-2 and E-3 summarize the preliminary performance and design criteria used for this evaluation. Because the alternative evaluations were preformed prior to the finalization of the system performance and design criteria, the values in Tables E-2 and E-3 may differ slightly with the criteria in Section 5 of this report.

E.3. Alternative Descriptions

The infrastructure alternatives considered the use of potable production wells, WSFs, a CAP surface WTP, regional recharge facilities, and City-owned surface spreading basins. The following specific alternatives were identified for evaluation:

- Alternative 1: All well supply
  - Alternative 1A: CAP Recharge at regional recharge facilities
  - Alternative 1B: CAP recharge at City-owned spreading basin recharge facilities
- Alternative 2: All well supply with fewer WSFs and larger interconnected systems
- Alternative 3: CAP WTP with wells for additional production and backup supply

E.3.1. Alternative 1: All Well Supply

Under this alternative, the City will continue with its current philosophy for water supply, treatment, and distribution. All potable water will be supplied with wells and the City's CAP allocation will be recharged. The system will be configured as follows:

- Each WSF will serve a 4 to 6 square mile area, creating 31 WSFs in addition to the WSFs already operating in SPA 1 and 2.
- The number of wells needed for each WSF will depend on the service area demand for the specific WSF.
- WSFs will consist of treatment (e.g., arsenic treatment and disinfection), storage, and booster pumping.
- Each WSF will have its own backup supply to ensure firm capacity (i.e., each WSF will provide the required production capacity with the largest well out of service). Emergency interconnects with the surrounding WSFs will also be provided.
- CAP water will be recharged.

Table E-2.
Preliminary Drinking Water System Performance and Design Criteria

			Used for Infrastructure Alternatives
Peaking Factors		**Max Day Peaking Factor**	2
		Peak Hour Peaking Factor	3
Wells/Production Facility		**Production Capacity**	1.1 x Maximum Day Demand
		Firm Capacity	Must Meet Maximum Day Demand with Largest Well Out of Service
Storage Facility		**Equalizing Storage**	20 % of Maximum Day Demand
		Fire Storage	Fire Flow x Duration
		Emergency Storage	10 % of Maximum Day Demand
		Max Height	-
Pipe	**Distribution**	**Velocity**	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Day + Fire Flow
	Transmission	**Velocity**	< 5 ft/s
		Headloss	< 2 ft / 1000 ft
		Design Criteria	Maximum Day + Fire Flow
	Fire Flow	**Velocity**	< 10 ft/sec
Fire Flow		**Single Family Residential**	2,000 gpm for 2 hours
		Multi Family Residential	2,000 gpm for 2 hours
		Commercial	3,000 gpm for 3 hours
		Industrial	3,000 gpm for 3 hours
System Pressure		**Maximum Pressure**	100 psi
		Max Day/Peak Hour Conditions	40 psi to 100 psi
		Fire Flow Conditions	20 psi Minimum
Booster Station		**With Storage**	Maximum Day + Fire Flow
		Without Storage	
		Firm Capacity	Largest Pump Out of Service

There were two alternatives for recharging CAP water: recharge at a regional recharge facility or recharge at City-owned spreading basins. If regional recharge is used, the City will continue its agreement with CAWCD regarding recharge. CAWCD will determine where the water is recharged. No additional infrastructure was required for this recharge method. Recharge at the Hieroglyphic Mountain Recharge Facility was preferred (if possible) because it would contribute to the physically available water beneath the City's planning area. If City-owned recharge was used, the City would be responsible for

Table E-3.
Preliminary Spreading Basin Design Criteria

Parameter	Used for Infrastructure Alternatives
Loading Rate (ft/year)	122
Loading Rate: Infiltration Rate (%)	33
Infiltration Rate (ft/day)	1
Wet/Dry Ratio	0.50
Application Period (days)	4
Drying Period (days)	8
Number of Basins (#)	3
Basin Depth (ft)	5
Sidewall Slope (Rise:Run)	1:3
Ramp Gradient (%)	10
Distance Between Basins (ft)	12

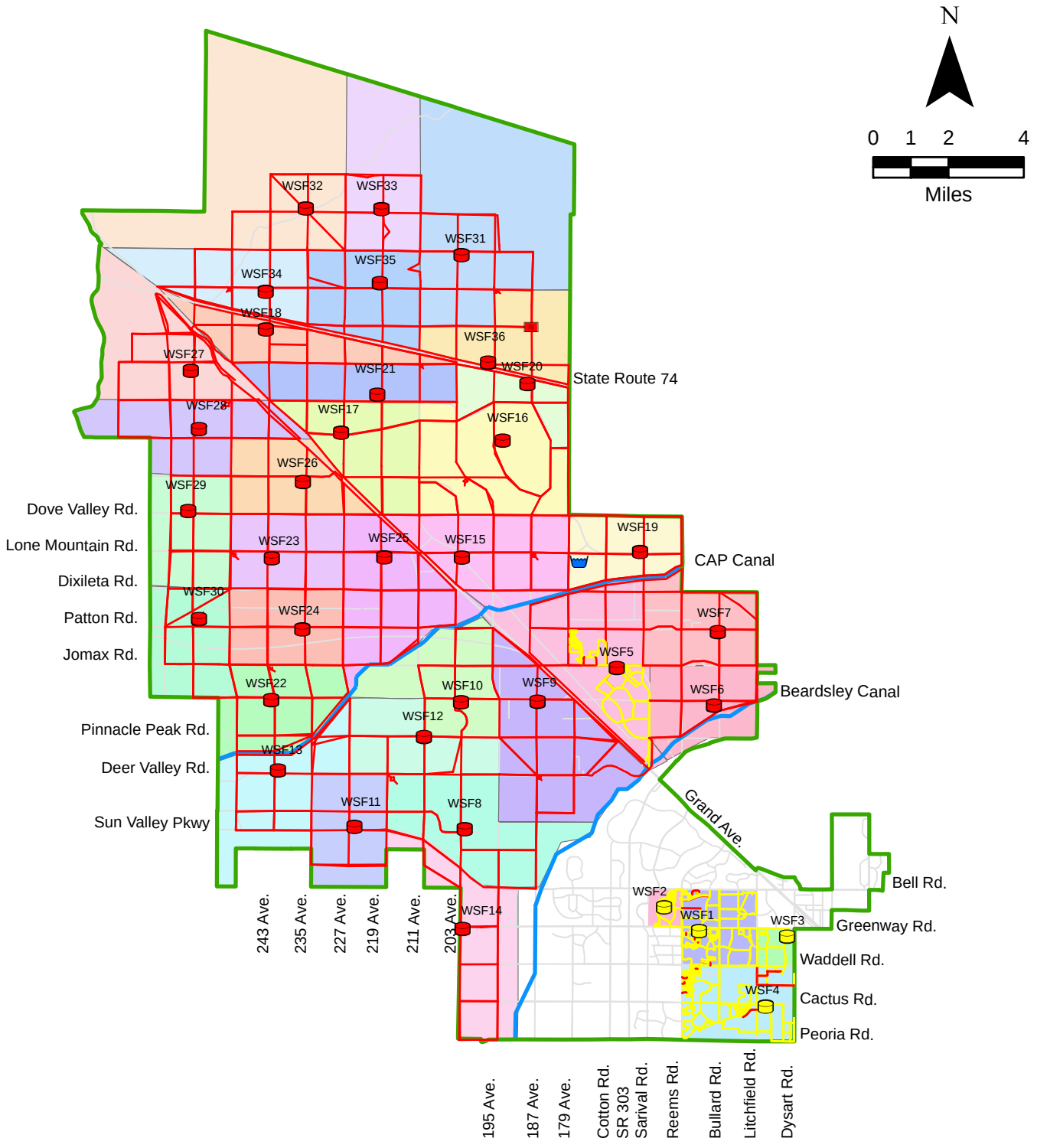
constructing and maintaining the recharge basins as well as the infrastructure to convey the water from the canal to the recharge location. The proposed infrastructure layouts for Alternatives 1A and 1B, including pipes and water supply facilities, are shown on Figures E-1 and E-2, respectively.

E.3.2. Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

This alternative was similar to Alternative 1 in that wells supply all potable water and the City's CAP allocation was recharged. However, in this alternative, the service area and size of the WSFs will increase, creating a more interconnected system (Figure E-3). In general, each WSF in this alternative was a combination of two or three WSFs identified in Alternative 1. The WSFs currently operating in SPAs 1 and 2 will remain, resulting in a total of 16 WSFs. Elevation changes, geographic features, and anticipated demand patterns were used to determine the most appropriate configuration of the combined, larger WSFs. Either method of recharging CAP water could be used in this alternative; however, for the purposes of the cost evaluation, regional recharge was selected because it was the lower cost option identified in the analysis of Alternative 1.

E.3.3. Alternative 3: CAP Surface WTP with Wells for Additional Production and Backup Supply

In this alternative, instead of recharging CAP water, a CAP WTP will be constructed to treat the surface water prior to delivering to customers for potable use. The capacity of the WTP was assumed to be 13 mgd, which included the City's existing CAP allocation and the potential additional CAP allocation from Circle City Water Company. The



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Proposed CAP Recharge

- CAP Hieroglyphics Facility

Water Supply Facilities

- Existing
- Proposed and/or Improved

Distribution System Pipelines

- Existing
- Proposed and/or Improved

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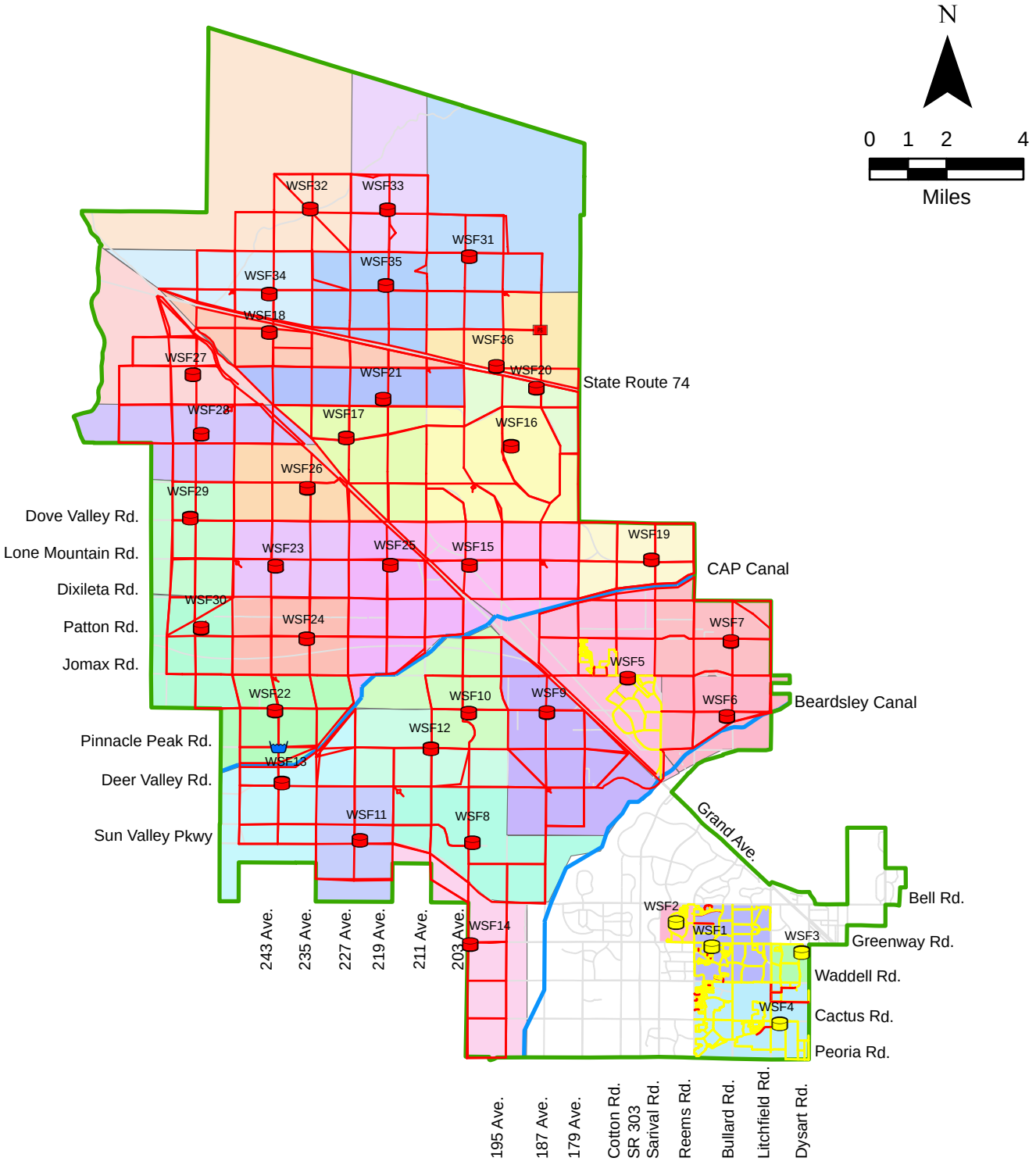
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1A: All Well Supply with CAP Recharge at Regional Recharge Facilities

July 2009

Figure E-1

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-1 Alternative 1A.mxd



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Proposed CAP Recharge

- City-owned Facility

Distribution System Pipelines

- Existing
- Proposed and/or Improved

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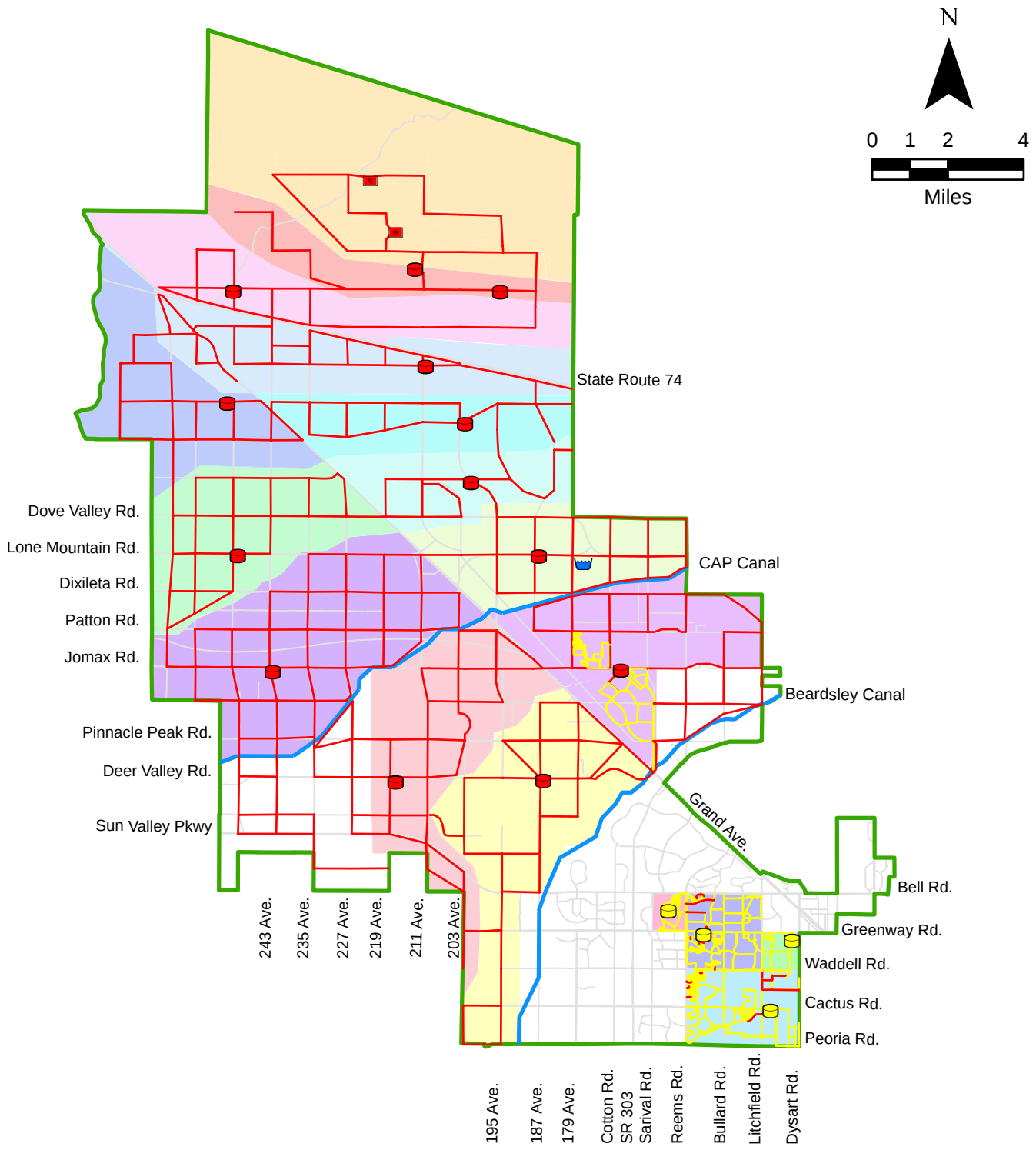
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1B: All Well Supply with CAP Recharge at City-Owned Spreading Basin Recharge Facilities

July 2009 | **Figure E-2**

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-2 Alternative 1B.mxd



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing

Additional Distribution Booster Stations

- Proposed

Proposed CAP Recharge

- CAP Hieroglyphics Facility

Distribution System Pipelines

- Existing
- Propsed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

July 2009

Figure E-3

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure E-3 Alternative 2.mxd

remainder of the City will be supplied with wells and the infrastructure for this alternative (shown on Figure E-4) will be similar to the distribution network shown for Alternative 2. The CAP WTP will be located near the intersection of the CAP Canal and Grand Avenue in SPA 5 and will serve customers generally in SPA 5.

Additional wells will be provided in this alternative to back up the CAP WTP in the event of a CAP Canal outage or shortage. Within the more than 20-year operational history of the CAP Canal in Arizona, maintenance outages have been minimal and typically occur in the winter. In the past, operators of the CAP system have also chosen to repair major portions of the delivery system (e.g., the corrosion problems associated with certain siphon crossings of major drainages) during the winter when domestic and agricultural demands for water are reduced. The CAP does routine shutdown of the Surprise delivery portions of the CAP pumping system in the summertime for maintenance; however, the maintenance is scheduled such that sufficient pumping capacity is maintained to satisfy all summertime demands. CAP shortages are even rarer. During times of shortages, however, the City would institute measures to reduce water demands in addition to using all available wells. The City of Peoria bases its planning for CAP WTPs to back up the plants with wells for average day demand conditions. As such, providing a backup well supply to serve an average day demand was considered appropriate for this analysis.

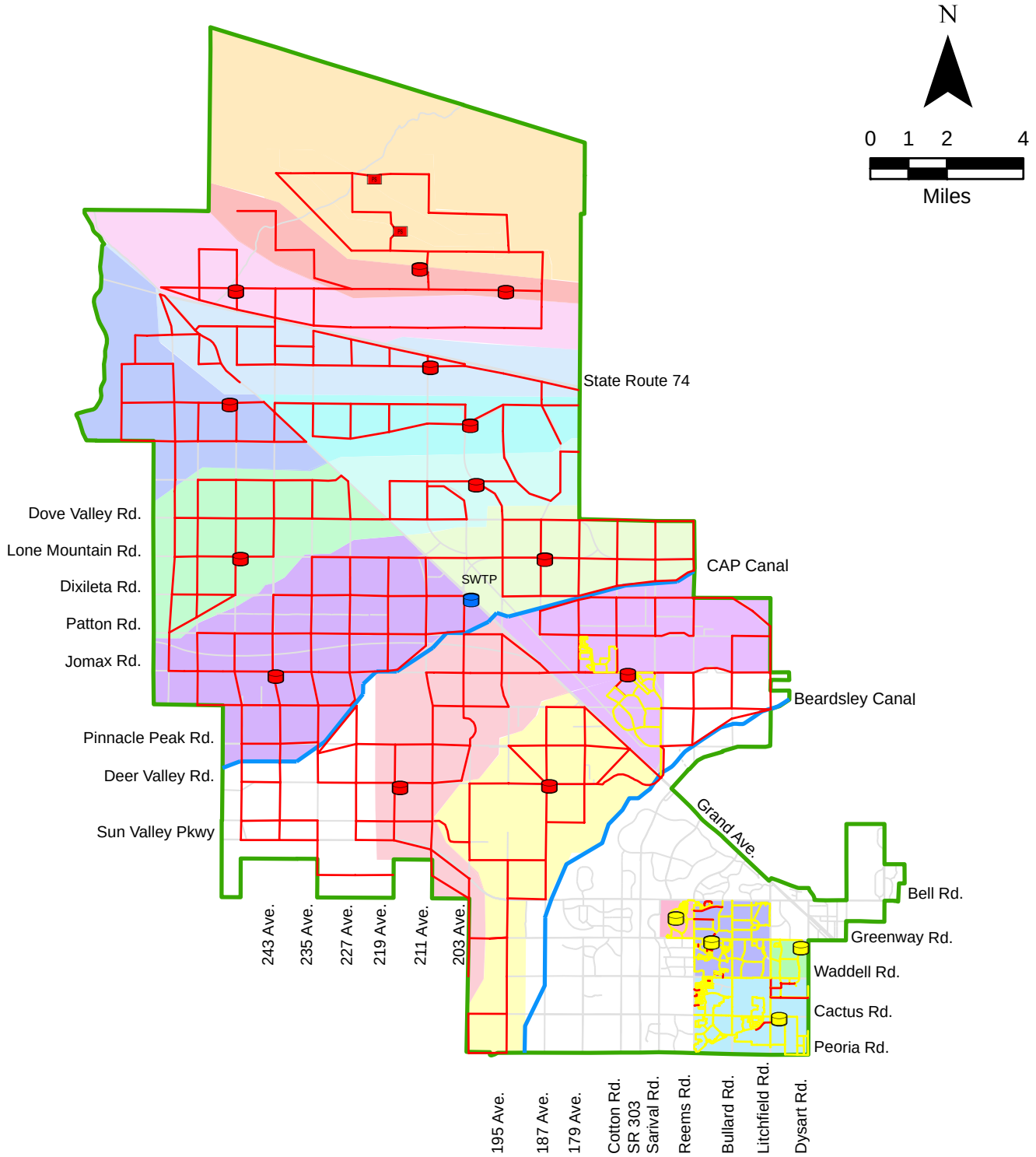
E.4. Water System Improvements

Improvements to the existing water system and future infrastructure were sized using the built-out demands from the Demand Module and peak demand and fire flow scenarios described above. The results for each alternative, including the number of WSFs, number of wells, amount of storage, booster pumping capacity, pipeline lengths, and necessary recharge are summarized in this section.

When analyzing the existing system in SPA 1 for fire flow under build-out demand conditions, additional deficiencies were identified (Section 5 of the Water Infrastructure component of the *Integrated Water Master Plan*). The improvements needed to overcome these deficiencies were common to all alternatives and, as such, have been added to each alternative.

E.4.1. Alternative 1: All Well Supply

Because the only difference between alternatives 1A and 1B was the method of recharge, the distribution system layouts were identical (Figures E-1 and E-2). This alternative followed the City's current philosophy of having individual WSFs serving an area of 4-6 square miles. The WSFs in some areas may be slightly larger due to the boundaries of existing, known, or currently planned developments in the municipal planning area.



Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved
- Proposed CAP SWTP

Additional Distribution Booster Stations

- Proposed

Distribution System Pipelines

- Existing
- Propsed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 3: CAP Surface WTP with Wells for Additional Production and Backup Supply

July 2009 | **Figure E-4**

M:\4957002\GIS\Project_MXDs\R-2-FINAL\Figure E-4 Alternative 3.mxd

E.4.1.1. Water Supply Facilities (WSFs)

The City's water supply facilities typically consist of treatment (e.g., arsenic or fluoride removal, disinfection, etc.), a storage reservoir, and a booster pump station. Note that reclaimed water storage and booster pumping are often co-located with the potable infrastructure at the WSFs. A summary of the infrastructure present at each WSF along with the number of wells needed to supply each WSF is shown in Table E-4.

- **WSFs –** In addition to the five existing WSFs, Alternative 1 included 31 new WSFs. The size of the WSFs ranged from 2 mgd to 16 mgd, but a majority of these were 4 mgd to 7 mgd. Each new WSF had an estimated land requirement of two acres.
- **Wells -** Each of the 31 WSFs has its own set of wells supplying groundwater to it. The City's standard sets the maximum flow from a well at 1,500 gpm. The total capacity of the wells for a WSF was calculated using the preliminary system performance and design criteria. Each well will be located on a one-quarter acre parcel.
- **Storage** - The function of storage is to provide reserve supply for operational equalization, fire suppression reserves, and emergency needs. The storage was calculated using the system performance and design criteria.
- **Booster Stations** - The booster stations at the WSFs were designed to meet maximum day plus fire flow for that service area. In service areas with large elevation change, booster pumps are used to pump water to a higher elevation at the appropriate pressure. There were 32 booster stations: 31 at the WSFs and one within the distribution system.

E.4.1.2. Piping

Two types of piping were included in the water alternatives, and a summary of both types piping is shown in Table E-5.

- **Well transmission mains** refer to the pipelines carrying groundwater from the wells to the WSFs. Spacing of the wells and sizing of the transmission mains were based on the City's existing well systems. It was assumed that each well would be located a minimum of 0.5 miles apart from each another and a maximum of three wells would feed into each transmission main.
- **Distribution pipes** are used to convey water from the storage reservoirs at the WSFs to the customers throughout the distribution network. Although the mains cross from one service area to the other, they are closed at service area boundaries. Thus, a main in a particular service area only carries the demand to serve that area.

Table E-4.
Drinking Water Supply Infrastructure for Alternative 1

Map ID	Water Supply Facility Description	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station Requirements	
					Capacity (gpm)	TDH (ft)
SPA 1						
WSF1	**Ashton Ranch** [1]	7	--	--	--	--
WSF2	**Mountain Vista Ranch** [1]	2	--	--	--	--
WSF3	**Roseview** [1]	2	--	--	--	--
WSF4	**Rancho Gabriela** [1]	7	--	--	--	--
SPA 2						
WSF5	**Desert Oasis** [1]	16[2]	8	1.9	4,500	220
WSF6	**Rancho Mercado**	7	5	2.8	5,123	231
WSF7	**R-58**	4	4	1.9	2,921	407
SPA 3						
WSF8	**Surprise Foothills**	13	8	4.6	9,270	213
WSF9	**Austin Ranch**	13	8	4.4	8,371	250
WSF10	**R-52**	8	6	3	5,627	246
WSF11	**Mesquite Mountain Ranch**	7	5	2.7	4,936	401
WSF12	**Fox Trails**	7	5	2.7	4,864	244
WSF13	**R-48**	6	4	2.3	4,052	293
WSF14	**R-55**	5	4	2	3,179	280
SPA 4						
WSF15	**Sunhaven Ranch**	12	8	4.1	8,236	240
WSF16	**Grand Vista**	10	7	3.7	7,238	219
WSF17	**BNSF Commercial**	5	4	2	3,203	310
WSF18	**R-40**	4	4	1.8	2,806	176
WSF19	**Marisol Ranch**	3	3	1.5	2,183	272
WSF20	**R-39**	3	3	1.4	1,904	363
WSF21	**R-36**	2	3	1.1	1,115	532
SPA 5						
WSF22	**R-47**	7	5	2.7	4,904	241
WSF23	**R-44**	6	5	2.4	4,245	233
WSF24	**R-46**	6	5	2.4	4,211	250
WSF25	**Walden Ranch**	6	5	2.4	4,150	239
WSF26	**Broadstone Ranch**	5	4	2	3,257	304
WSF27	**R-41**	5	4	2	3,212	277
WSF28	**R-42**	4	3	1.7	2,631	226
WSF29	**R-43**	4	3	1.7	2,617	303
WSF30	**R-45**	4	3	1.7	2,459	322
SPA 6						
WSF31	**Lake Pleasant 5000**	10	6	3.4	6,610	539
WSF32	**R-60**	7	5	2.6	4,596	258
					850	465
WSF33	**R-29**	5	4	2.1	3,471	400
WSF34	**R-31**	4	4	1.9	3,094	320
WSF35	**R-34**	4	3	1.7	2,631	376
WSF36	**R-38**	2	3	1.3	1,610	403

Notes:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF

Table E-5.
Summary of Pipe Improvements for Alternative 1

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	22,900
12	240,200	400
16	-	2,461,300
20	147,800	41,700
24	5,300	81,100
30	-	600
Total	393,300	2,608,000

E.4.1.3. Pressure Reducing Valves

Eleven pressure reducing valves (PRVs) were needed in this alternative in order to reduce the high pressure (more than 100 psi) experienced in some areas due to large elevation change within the service area. The PRVs range in size from16 inches to 36 inches in diameter.

E.4.1.4. CAP Recharge

For Alternative 1A, CAP water will be recharged at the Hieroglyphic Mountains Recharge Facility. No additional infrastructure is needed for this alternative.

For Alternative 1B, CAP water will be recharged in SPA 5 near the intersection of 243rd Avenue and Pinnacle Peak Road. This location was selected because it is favorable from a hydrogeologic perspective (i.e., the depth to groundwater is high), and it is located a sufficient distance from the surrounding regional recharge projects. To accommodate the CAP allocations, 129 acres of spreading basins will be needed. A 30-inch transmission main (2,640 ft) was included to convey the CAP water from the canal to the recharge location. It was assumed that the water would be conveyed by gravity.

E.4.2. Alternative 2: All Well Supply with Fewer WSFs and a Larger Interconnected System

Alternative 2 is similar to Alternative 1 in that all water is supplied from wells; however, it is characterized by larger service areas and fewer WSFs than Alternative 1. The water distribution system in this alternative is divided into 12 preliminary pressure zones (Figure E-3). The existing infrastructure in SPA 1 is combined together as one pressure zone and the remainder of the planning area is divided into 11 pressure zones, each spanning approximately 120 feet in elevation change. Physical boundaries such as canals and major roads were considered while delineating the pressure zone boundaries. Each pressure zone was further divided according to the SPA boundaries such that water from one SPA was not supplied to another SPA. Interconnects have been provided between

the pressure zones and SPAs that can be opened to move water across zone boundaries in case of emergencies. The interconnects will remain closed under normal operating conditions.

E.4.2.1. Water Supply Facilities (WSFs)

Similar to Alternative 1, the WSFs in this alternative consist of treatment, storage reservoirs, and a booster pump station. However, due to system hydraulic constraints, an additional storage facility and three additional booster stations were located within the distribution system in this alternative. A summary of the infrastructure present at each WSF along with the numbers of wells needed is presented in Table E-6.

- **WSFs** – In addition to the five existing WSFs, Alternative 2 includes 11 new WSFs. In general, each pressure zone contains one or two WSFs. However, because accessing groundwater is more challenging in mountainous regions, pressure zones 10, 11, and 12 do not have their own WSFs, but instead they are supplied water from a storage tank in pressure zone 9. No changes to the existing WSFs are needed. Because the WSFs have a larger capacity and will serve a larger area, 4 acres was assumed for each new WSF.
- **Wells -** Each WSF is supplied by several wells using the criteria described above. Each well will be located on a one-quarter acre parcel.
- **Storage -** Each WSF includes storage for equalization, fire flow, and emergency purposes. The storage tank in pressure zone 9 is sized to provide one maximum day demand to pressure zones 10, 11, and 12. The storage for other tanks was calculated using the method described above.
- **Booster Stations -** There are 14 new booster stations needed in this alternative (11 located at WSFs and 3 located in the distribution system). In addition, the capacity of the booster station at Desert Oasis was increased.

E.4.2.2. Piping

Transmission piping and distribution piping serve the same functions as described in Alternative 1. The piping summary for Alternative 2 is shown in Table E-7. Because this alternative is more interconnected, fewer pipes are needed to serve the area. Although the total length of pipes needed in Alternative 2 is less than in Alternative 1, the piping diameters tend to be larger.

E.4.2.3. PRVs

There were no PRVs needed in this alternative.

E.4.2.4. CAP Recharge

CAP water will be recharged at the Hieroglyphic Mountains Recharge Facility. No additional infrastructure was needed for this alternative.

Table E-6.
Water Supply Infrastructure for Alternative 2

Map ID	Water Supply Facility Description	Pressure Zone	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station	
						Capacity (gpm)	TDH (ft)
WSF1	Ashton Ranch [1]	1	7	--	--	--	--
WSF2	Mountain Vista Ranch [1]	1	2	--	--	--	--
WSF3	Roseview [1]	1	2	--	--	--	--
WSF4	Rancho Gabriela [1]	1	7	--	--	--	--
WSF5	Desert Oasis [1]	2 and 3	25[2]	12	4.6	15,000	220
WSF37	R-61	2	21	12	6.9	15,000	203
WSF38	R-63	3	31	17	9.8	21,400	167
WSF39	R-64	4	35	19	11.2	24,600	187
WSF40	R-65	4	12	8	4.3	8,500	152
WSF42	R-67	5	12	8	4.3	8,600	140
WSF41	R-66	5	14	9	4.8	9,800	182
WSF43	R-68	6	5	4	2.2	3,700	218
WSF44	R-75	6	5	4	2	3,350	240
WSF45	R-71	7	10	7	3.6	7,100	225
WSF46	R-72	8	8	5	2.9	5,400	225
WSF47	R-73	9	6	4	2.3	4,000	305
B1	T-3	10	NA	NA	16	11,800	238
B2		11	NA	NA	NA	7,000	230
B3		12	NA	NA	NA	4,000	300

NOTES:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF

Table E-7.
Summary of Pipes Improvements for Alternative 2

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	25,300
12	110,900	57,200
16	-	1,314,000
20	103,000	51,600
24	71,300	514,200
30	-	27,800
36	-	31,700
Total	285,200	2,021,800

E.4.3. Alternative 3: CAP WTP with Wells for Additional Production and Backup Supply

Alternative 3 is very similar to Alternative 2 except that the City's CAP allocations will be treated and distributed from a surface WTP (Figure E-4).

E.4.3.1. Water Supply Facilities (WSFs)

Similar to Alternative 2, the WSFs in this alternative consist of treatment, storage reservoirs, and a booster pump station. Further, an additional storage facility and three additional booster stations are located within the distribution system away from WSFs. The CAP WTP in this alternative is located within pressure zone 4. A summary of the infrastructure present at each WSF along with the numbers of wells needed is presented in Table E-8.

- **WSFs -** This alternative has the same number of WSFs as Alternative 2; however, because a surface WTP is provided, the size of the R-64 WSF in pressure zone 4 is smaller.
- **CAP WTP -** The CAP WTP will utilize conventional treatment technologies (coagulation/flocculation followed by filtration) to treat the water to potable water standards. Approximately 90 percent of the raw water will be recovered from the treatment process as potable water, resulting in approximately 11 mgd available for distribution. The remaining 10 percent will be lost in the solids handling process.
- **Storage –** Storage is provided at each WSF, including the CAP WTP. The storage volume was calculated as described in section 3. All the storage reservoirs, except for Tank T-3, are located at the WSFs.
- **Wells -** Each WSF is supplied by several wells using the criteria described in Section 3. In addition, the CAP WTP has back up wells in case of interruption in CAP water supply. The back wells can provide one average day of demand to the CAP WTP's service area. Each well will be located on a one-quarter acre parcel.
- **Booster Stations –** As compared to Alternative 2, one additional booster station is present in the alternative at the CAP WTP. Also, there is a reduction in the capacity of the booster station at WSF R-64.

E.4.3.2. Piping

Transmission piping and distribution piping serve the same functions as described in Alternative 1. The total length of the improvement pipes in this alternative is the same as in Alternative 2, but they differ in sizes needed. There are fewer 16 inch pipes and more 24 inch and 30 inch pipes in Alternative 3. The piping summary for Alternative 3 is shown in Table E-9.

E.4.3.3. PRVs

There are no PRVs needed in this alternative.

E.4.3.4. CAP Recharge

Because CAP water will be used at the surface water treatment plant, no recharge facilities for CAP water were needed.

Table E-8.
Water Supply Infrastructure for Alternative 3

Map ID	Water Supply Facility Description	Pressure Zone	WSF Capacity (mgd)	Number of Additional Wells	Additional Storage Required (MG)	Additional Booster Station Requirements	
						Capacity (gpm)	TDH (ft)
WSF1	Ashton Ranch [1]	1	7	--	--	--	--
WSF2	Mountain Vista Ranch [1]	1	2	--	--	--	--
WSF3	Roseview [1]	1	2	--	--	--	--
WSF4	Rancho Gabriela [1]	1	7	--	--	--	--
WSF5	Desert Oasis [1]	2 and 3	25[2]	12	4.6	15,000	220
WSF37	R-61	2	21	12	6.9	15,000	203
WSF38	R-63	3	31	17	9.8	21,400	167
SWTP	CAP Surface WTP	4	11	4 [3]	4	7,900	301
WSF39	R-64	4	24	14	7.8	16,600	226
WSF40	R-65	4	12	8	4.3	8,500	152
WSF42	R-67	5	12	8	4.3	8,600	140
WSF41	R-66	5	14	9	4.8	9,800	182
WSF43	R-68	6	5	4	2.2	3,700	218
WSF44	R-75	6	5	4	2	3,350	240
WSF45	R-71	7	10	7	3.6	7,100	225
WSF46	R-72	8	8	5	2.9	5,400	225
WSF47	R-73	9	6	4	2.3	4,000	305
B1	T-3	10	NA	NA	16	11,800	238
B2		11	NA	NA	NA	7,000	230
B3		12	NA	NA	NA	4,000	300

Notes:
(1) Existing WSF
(2) Includes the existing capacity of Desert Oasis WSF
(3) Backup supply to serve average day demand

Table E-9.
Summary of Pipes Improvements for Alternative 3

Diameter (in)	Transmission Main Length (feet)	Distribution Pipe Length (feet)
8	-	25,300
12	110,900	57,200
16	-	1,324,800
20	105,600	51,600
24	66,000	498,100
30	-	32,600
36	-	31,700
Total	282,500	2,021,300

E.5. Basis of Costs

Preliminary capital and O&M cost estimates were developed for the required system improvements and upgrades identified for each drinking water infrastructure alternative. The cost estimates presented herein are based on capital improvement plan budgets, bid tabulations, and unit cost data from the cities of Surprise, Phoenix, Peoria, Avondale, and El Mirage. Existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment were also used to refine the estimated costs when necessary. The level of accuracy for the cost estimates corresponds to the Class 4 estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating is approximate and generally made without detailed engineering data and site layouts, but is appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate is minus 15 to plus 20 percent in the best case and minus 30 percent to plus 50 percent in the worst case.

The unit capital costs include materials of construction, installation, contractor costs (overhead, profit, bonding, mobilization), and engineering. For infrastructure calculated from equipment and concrete costs, a 30 percent level of planning contingency was added (i.e. CAP WTP). The unit O&M costs include labor, power, chemicals, maintenance, and materials. All costs are in October 2008 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 8,623.

The relative economic feasibility of the alternatives was compared based on an equivalent present worth cost basis. The equivalent present worth cost for each alternative is the sum of total capital cost plus the estimated annual O&M cost, annualized over a 20-year study period at an interest rate of 7 percent.

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F. Wastewater, Reclaimed Water, and Recharge Infrastructure Alternatives

This appendix provides additional information on the development of the wastewater, reclaimed water, and recharge infrastructure alternatives.

F.1. Future System Demand Scenario

The demand set used for the wastewater, reclaimed water, and recharge system evaluations was the Mid-Population Scenario (i.e., population of approximately 700,000 at build-out) identified in the Water Resources component of the *Integrated Water Master Plan*. This scenario involves collecting wastewater from all customers within the City's sewer planning area, and reclaimed water service to all private water company service areas within the City's MPA, with the exception of the Arizona American Water Company (AAWC) and City of El Mirage service areas. In this scenario, the City will plan to control future development densities to balance water demands with available water supplies.

As described in the Water Resources component of the *Integrated Water Master Plan*, indoor and outdoor demands will be served with potable water and landscape (large irrigation) demands will be served via the reclaimed water distribution system. It is assumed that all potable water used indoors returns through the wastewater system. The reclaimed water availability is assumed to be 90 percent of the wastewater generated throughout the area.

Preliminary build-out wastewater flows, reclaimed water availability, and landscape (large irrigation uses served with reclaimed water) demands were obtained from the Demand Module. These values, shown in Table F-1, were used for the preliminary wastewater, reclaimed water, and recharge infrastructure evaluations. Because the alternative evaluations were preformed prior to the completion of the Water Resources component of the *Integrated Water Master Plan*, the demands used for the evaluation varied slightly from the demands used to phase the selected alternative in Section 7 of the Water Infrastructure component of the *Integrated Water Master Plan*.

All modeling of future scenarios was conducted for the build-out condition. As such, the comparisons presented in this memo represent infrastructure and costs at build-out. Based on comments received from the City, the selected alternative was remodeled prior to developing a phasing and implementation schedule for 2020 and build-out conditions.

Table F-1.
Build-out Wastewater Flows, Reclaimed Water Availability, and Landscape (Reclaimed Water) Demands Used for Infrastructure Alternatives

Special Planning Area	Annual Average Wastewater Flow (mgd)	Reclaimed Water Availability (mgd)	Landscape (Reclaimed Water) Demand (mgd)
SPA 1	20.9	18.9	2.2
SPA 2	9.1	8.2	1.6
SPA 3	20.2	18.2	2.4
SPA 4	12.2	11.0	2.5
SPA 5	15.4	13.9	3.5
SPA 6	10.7	9.6	3.1
TOTAL	88.6	79.7	15.3

F.2. System Performance and Design Criteria

Tables F-2 through F-4 summarize the preliminary performance and design criteria used for this evaluation. Because the alternative evaluations were preformed prior to the finalization of the system performance and design criteria, the values in Tables F-2 through F-4 may differ slightly with the criteria in Section 5 of this report.

Table F-2.
Preliminary Collection System Performance and Design Criteria Summary

Element	Design Criteria	Used for Infrastructure Alternatives
Maximum Month Flow	Peaking Factor (based on average annual flow)	1.2
Peak Hour Flow	Peaking Factor (based on maximum month flow)	2.5
Gravity Sewers	Depth Ratio	<0.8
Force Mains	Velocity Range	2 ft/s - 8 ft/s
Pump Stations	Firm Capacity	Exceeds Peak Flow

F.3. Alternative Descriptions

The wastewater and reclaimed water infrastructure alternatives were developed in a workshop with the City's Steering Committee and Technical Committees. The following general alternatives were identified for evaluation:

- Alternative 1: Construct and Operate 6 WRFs
- Alternative 2: Construct and Operate 4 WRFs
- Alternative 3: Construct and Operate 3 WRFs

Table F-3.
Preliminary Reclaimed Water System Performance and Design Criteria Summary

Design Parameters			Used for Infrastructure Alternatives
Peaking Factors		Maximum Day	2 x Average Day Demand
		Peak Hour	3 x Maximum Day Demand
Reclaimed Water Production			0.9 x Wastewater Treatment Capacity
Storage Facility			Maximum Day Demand
Pipe Sizing	Distribution	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Peak hour of maximum day
	Transmission	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Recharge Demand
	Recharge Mains	Velocity	< 5 ft/s
		Headloss	<10 ft/ 1000 ft
		Design Criteria	Maximum Recharge Demand
System Pressure		Maximum Pressure	80 psi
		Minimum Pressure (Peak Hour Conditions)	25 psi
Booster Station Design Criteria		at WSF	Peak Hour
		at Distribution System	
		at WRF	Maximum Recharge
		at Transmission Mains Boosting to WSF only	Maximum Day Demand

Each alternative is generally described in the following sections, followed by detailed descriptions, including design considerations, concept schematics, and anticipated infrastructure requirements (WRFs, collection system piping, reclaimed water piping and pumps, and recharge basins).

F.3.1. Alternative 1: Construct and Operate 6 WRFs

Under this alternative, the City will design and construct a WRF in each SPA (Figure F-1). In essence, the City would continue with recommendations provided in the previous wastewater and reclaimed water master plans. Reclaimed water demands (large irrigation

Table F-4.
Preliminary Recharge System Performance and Design Criteria

Parameter	Used for Infrastructure Alternatives
Loading Rate (ft/year)	122
Loading Rate: Infiltration Rate (%)	33
Infiltration Rate (ft/day)	1
Wet/Dry Ratio	0.50
Application Period (days)	4
Drying Period (days)	8
Number of Basins (#)	3
Basin Depth (ft)	5
Sidewall Slope (Rise:Run)	1:3
Ramp Gradient (%)	10
Distance Between Basins (ft)	12

uses) will be met with reclaimed water from the 6 WRFs. Reclaimed water will be pumped from the WRF to storage and booster facilities that are co-located with water supply facilities (WSFs) throughout the municipal planning area (Figure F-2). All surplus reclaimed water will be recharged.

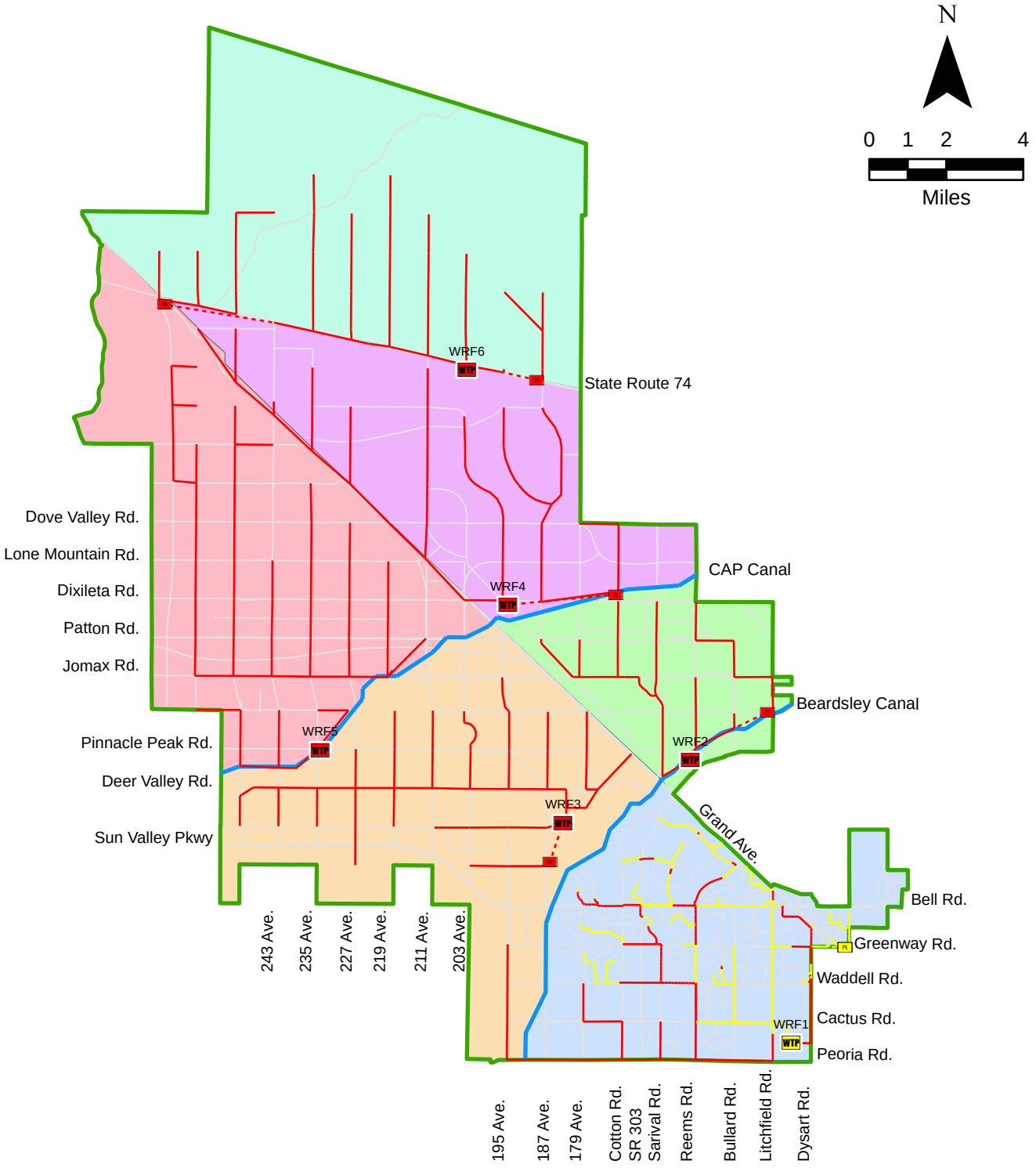
In this configuration, the wastewater collection systems in each SPA remained separate; no areas of one SPA are served by another SPA WRF except for the southernmost area of SPA 3, which conveys wastewater to the SPA 1 collection system. This diversion is common to all of the alternatives analyzed.

F.3.2. Alternative 2: Construct and Operate 4 WRFs

Under this alternative, the City will design and construct 4 WRFs: one each in SPAs 1, 2, 3, and 5 (Figure F-3). The SPA 1, 2, and 3 WRFs will receive flows from their respective SPA. The SPA 4 WRF will receive wastewater flows from SPAs 4, 5, and 6. Reclaimed water storage, distribution, and recharge will be similar to Alternative 1; however, reclaimed transmission mains and booster pumping will change (Figure F-4).

F.3.3. Alternative 3: Construct and Operate 3 WRFs

Under this alternative, the City will only design and construct 3 WRFs in SPAs 1, 2, and 3 (Figure F-5). Collection system flows from SPA 5 will be routed to the WRF in SPA 3. Flows from SPAs 4 and 6 will flow into the WRF in SPA 2. Reclaimed water storage, distribution, and recharge will be similar to Alternatives 1 and 2, but reclaimed water transmission and booster pumping will vary (Figure F-6).



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2
- SPA 3
- SPA 4
- SPA 5
- SPA 6

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1: 6 WRFs (Wastewater Infrastructure)

July 2009

Figure F-1

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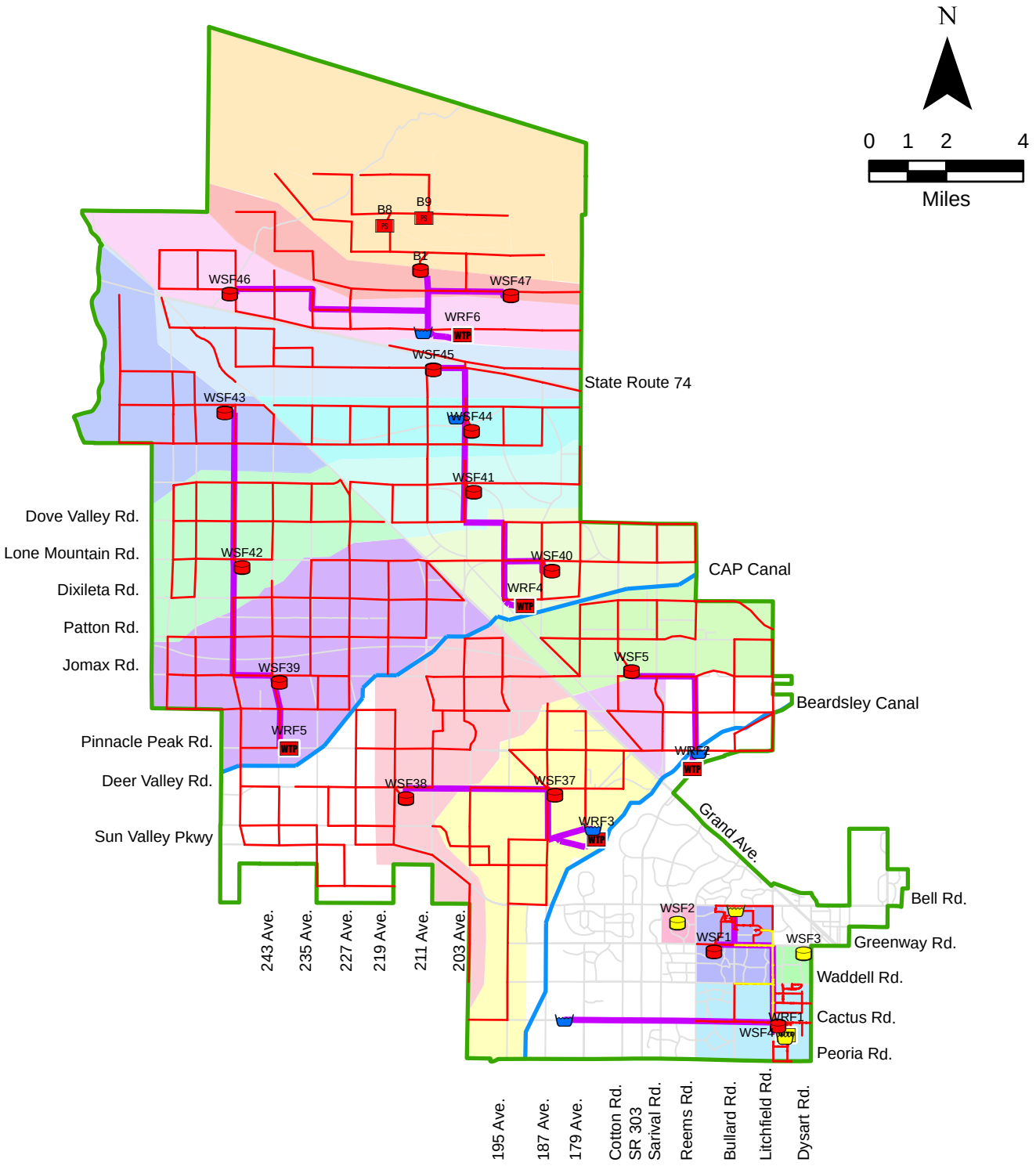

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Distribution Booster Stations

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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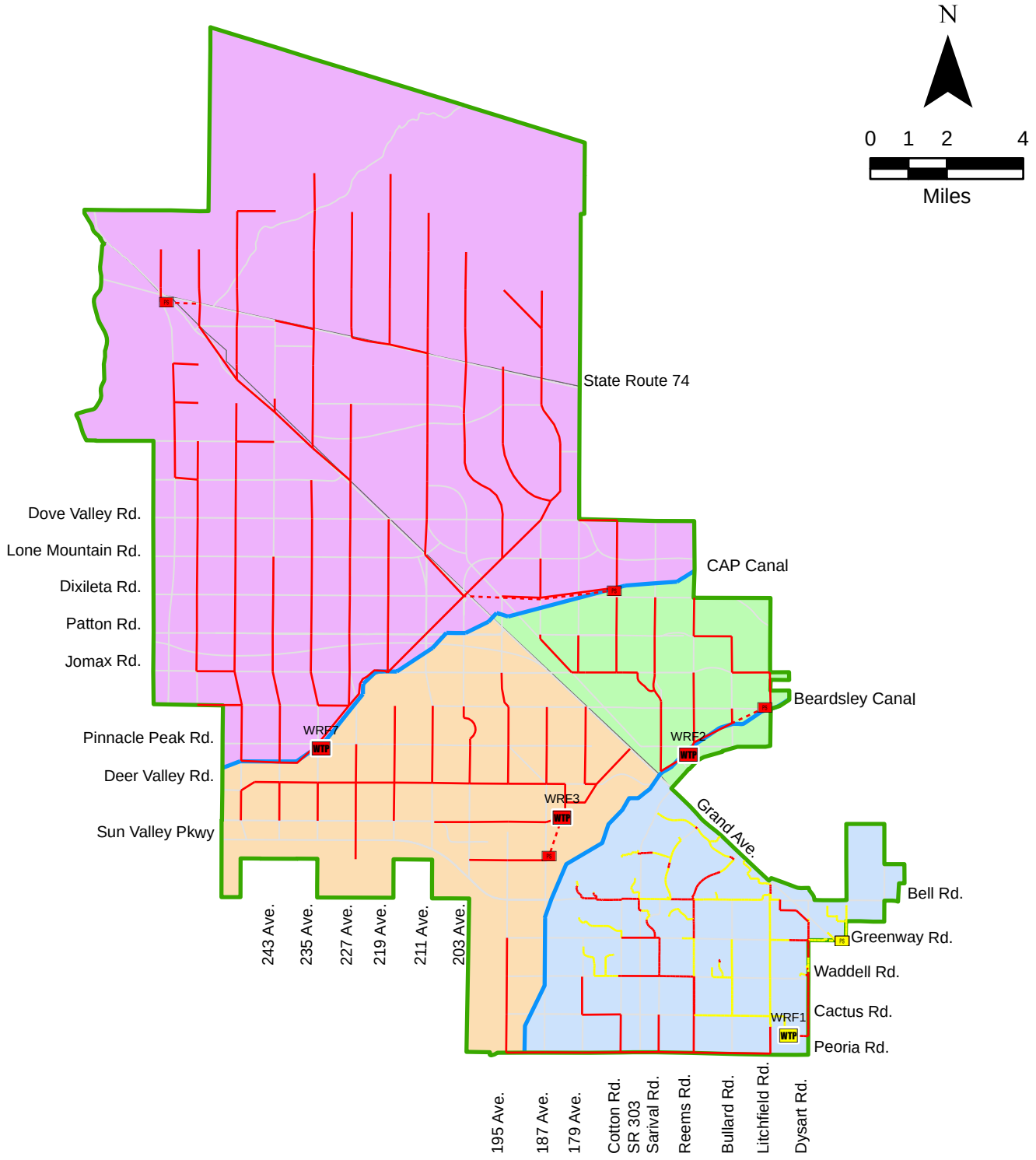
INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 1: 6 WRFs (Reclaimed Water Infrastructure)

July 2009

Figure F-2

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-2 6 WRFs RW.mxd



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2
- SPA 3
- SPA 4/5/6

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 4 WRFs (Wastewater Infrastructure)

July 2009

Figure F-3

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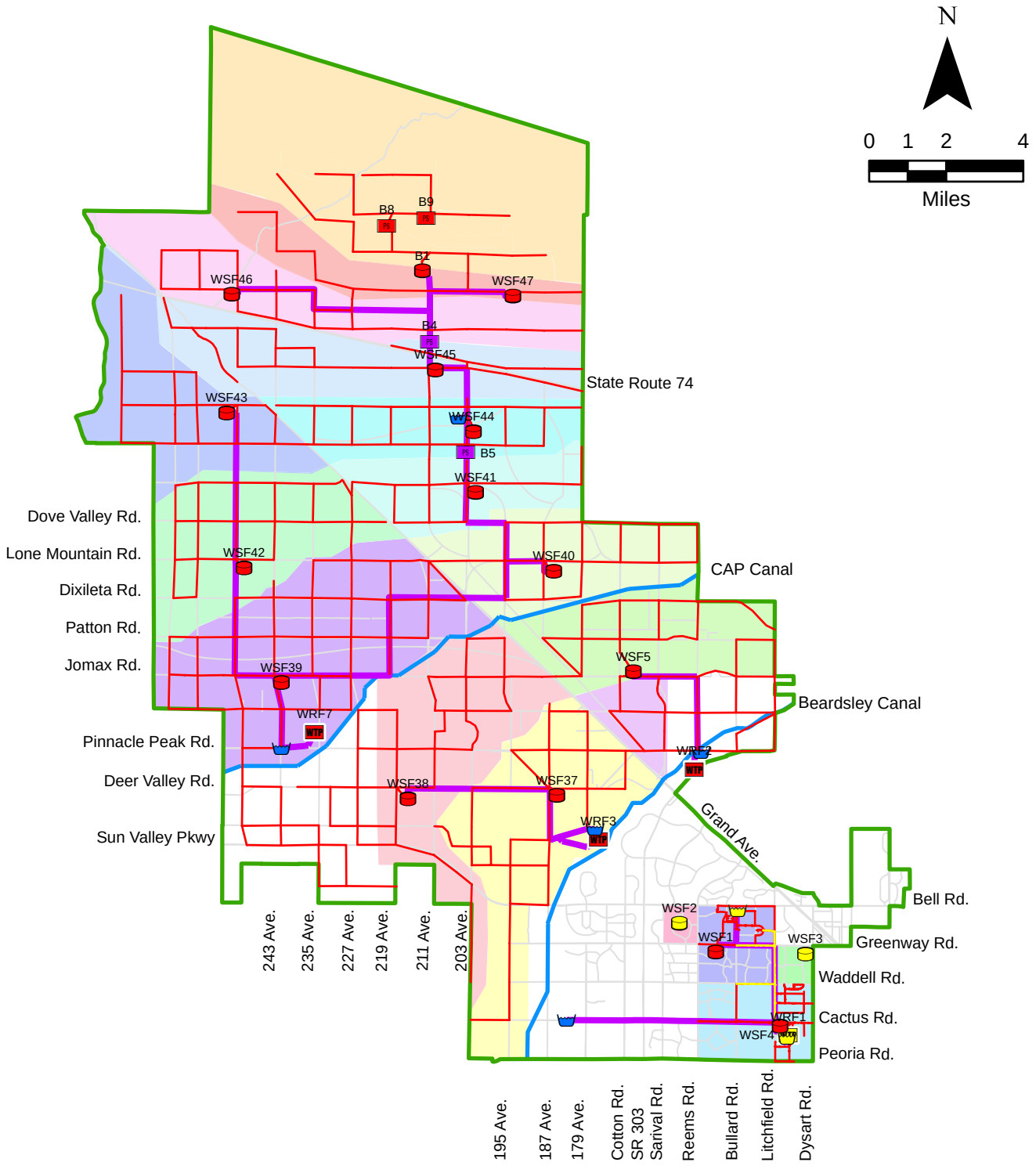

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Transmission Booster Station

- Proposed

Additional Distribution Booster Station

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 4 WRFs (Reclaimed Water Infrastructure)

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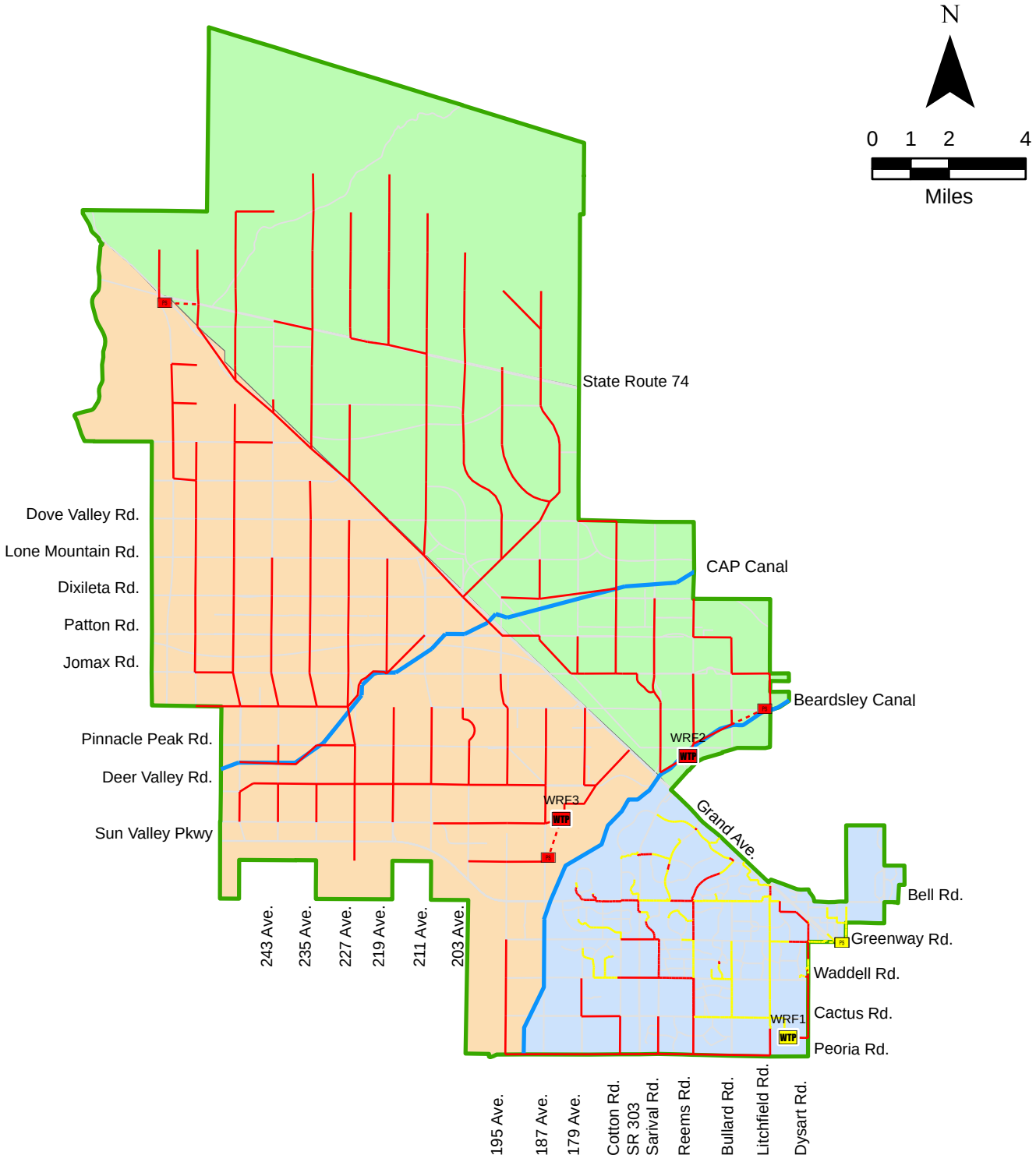
Figure F-4

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-4 4 WRFs RW.mxd



Legend

- Streets
- Canals
- Municipal Planning Area

Drainage Basins

- SPA 1
- SPA 2/4/6
- SPA 3/5

Water Reclamation Facilities

- Existing
- Proposed

Pump Stations

- Existing
- Proposed

Gravity Sewers

- Existing
- Proposed and/or Improved

Force Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 3: 3 WRFs (Wastewater Infrastructure)

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Figure F-5

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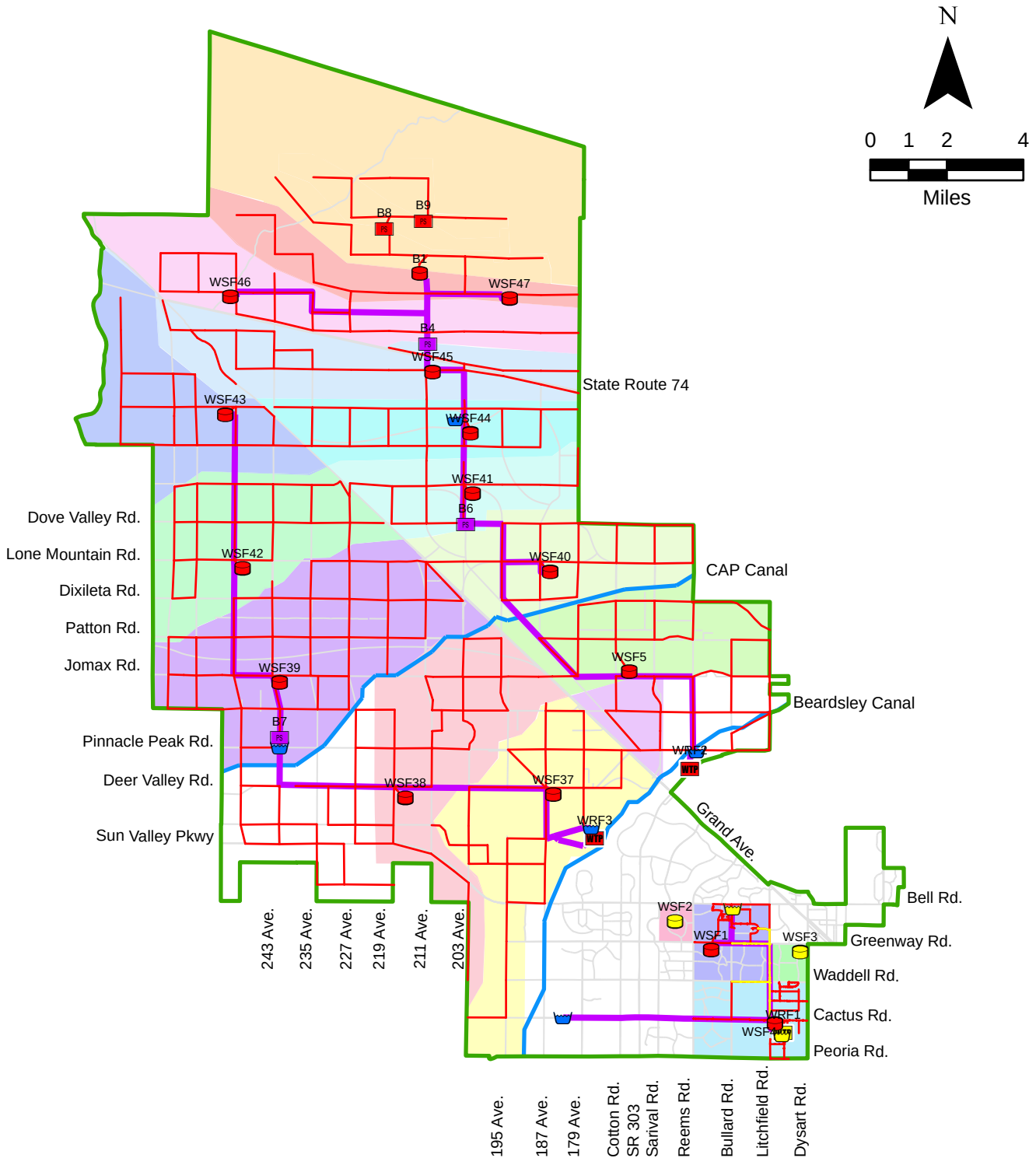

Legend

- Streets
- Canals
- Municipal Planning Area
- WSF Service Areas

Water Supply Facilities

- Existing
- Proposed and/or Improved

Water Reclamation Facilities

- Existing
- Proposed

Recharge Facilities

- Existing/Planned
- Proposed

Additional Transmission Booster Stations

- Proposed

Additional Distribution Booster Stations

- Proposed

Transmission Mains

- Proposed and/or Improved

Distribution Mains

- Existing
- Proposed and/or Improved

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INTEGRATED WATER MASTER PLAN:
WATER INFRASTRUCTURE

Alternative 2: 3 WRFs (Reclaimed Water Infrastructure)

July 2009

Figure F-6

M:\4957002\GIS\Project_MXDs\R-2_FINAL\Figure F-6 6 WRFs RW.mxd

F.4. Infrastructure Components for Alternatives

Each wastewater, reclaimed water, and reclaimed water recharge alternative will consist of the following components:

- Water Reclamation Facilities (WRFs)
- Gravity Collection System
- Pump Stations and Force Mains
- Reclaimed Water System (Transmission, Storage, Pumping, and Distribution)
- Recharge Facilities

F.4.1. Water Reclamation Facilities

The primary difference between the alternatives is the number and size of the WRFs. Using the appropriate sewer shed boundaries and the annual average wastewater loading from the Demand Module, the WRF capacities listed in Table F-5 were calculated. The collection system model assumes that each of the WRFs is able to accept the peak flow without any restrictions or back-ups into the collection system. With the exception of the SPA 1 WRF, all WRFs were assumed to use the membrane bioreactor (MBR) technology.

Table F-5.
Water Reclamation Facility Capacity and Land Requirements

	Facility Service Area	Annual Average Wastewater Load (mgd)	Land (acres)[1]
Alternative 1 (6 WRFs)	SPA 1	20.9	--
	SPA 2	9.1	92
	SPA 3	20.2	95
	SPA 4	12.2	93
	SPA 5	15.4	94
	SPA 6	10.7	93
Alternative 2 (4 WRFs)	SPA 1	20.9	--
	SPA 2	9.1	92
	SPA 3	20.2	95
	SPAs 4, 5, and 6	38.3	100
Alternative 3 (3 WRFs)	SPA 1	20.9	--
	SPAs 2, 4, and 6	32.0	99
	SPAs 3 and 5	35.6	100

NOTE:
(1) Land requirements assume no odor and noise control. Estimates were taken from the WateReuse Foundation WRF Decision Support System Tool. No additional land was needed for SPA 1.

F.4.2. Gravity Collection System

To develop sizing requirements for the future systems, the wastewater model was loaded with the preliminary, anticipated build-out flows determined using the Demand Module. In addition to the piping needed to serve new areas of the system, the system improvements summarized in this section also include items necessary for alleviating the system deficiencies identified in Section 5 in the main report.

The lengths of each diameter pipe needed at build-out for each alternative is summarized in Table F-6. As seen in the table, as the number of WRFs decreases, the total amount of collection system piping as well as the average diameter of the collection system piping increase. None of the piping in the alternatives listed below account for deterioration of the collection system that occurs as the natural part of aging. Any component of the collection system that is replaced as part of the City's buried infrastructure management program or otherwise known to be in a deteriorated station should be considered separate from these analyses.

Table F-6.
Gravity Sewer Upgrade Summary for the 6 WRF Alternative

Gravity Sewer Diameter (in)	Length of Gravity Sewer Improvement (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
8 inch	106,784	96,364	96,381
10 inch	161,321	122,254	117,923
12 inch	106,862	107,436	88,705
15 inch	224,452	193,555	213,484
18 inch	142,289	144,664	149,936
21 inch	111,991	127,698	133,334
24 inch	73,777	90,346	83,578
27 inch	37,030	72,469	73,202
30 inch	73,260	81,591	62,162
36 inch	68,478	57,620	39,736
42 inch	15,433	15,433	13,826
48 inch	21,045	8,822	27,226
54 inch	15,430	21,689	54,279
60 inch	-	-	16,021
66 inch	-	14,500	-
72 inch	-	-	4,430
78 inch	-	7,528	-
Total	**1,158,152**	**1,161,969**	**1,174,223**

F.4.3. Pump Stations and Force Mains

Due to the topography constraints, it was not possible to convey the wastewater to the WRF in each SPA entirely by gravity sewers. For areas that are located at lower elevation than the adjacent service area, it was necessary to include pump stations and force mains to transport the wastewater to a higher elevation in the collection system. The pump station capacities are assumed to be the firm capacity of the pump station to convey the peak flow, and the force mains were sized to maintain the optimal velocity range. All of the force mains discharge either to a trunk sewer or directly to the WRF. None of the force mains are manifolded.

As seen in Tables F-7 and F-8, as the number of WRFs decreases, the number of pump stations, the total pumping capacity, and the total length of force mains also decrease.

Table F-7.
Collection System Pump Station Improvements Summary

	Service Area	Capacity (gpm)	TDH[1] (ft)
Alternative 1 (6 WRFs)	SPA 2	2,938	115
	SPA 3	4,369	50
	SPA 4	7,623	120
	SPA 6 (east)	5,387	40
	SPA 6 (west)	5,625	85
	Total	30,968	NA
Alternative 2 (4 WRFs)	SPA 2	2,938	145
	SPA 3	4,369	40
	SPA 4	6,070	145
	SPA 6	1,316	180
	Total	14,693	NA
Alternative 3 (3 WRFs)	SPA 2	2,938	145
	SPA 3	4,369	40
	SPA 6	1,316	180
	Total	8,623	NA

NOTE:
(1) TDH requirements will change depend on the actual constructed elevations of the pump station wetwell and the discharge point.

F.4.4. Reclaimed Water System

The components of the reclaimed water system are as follows:

- **Reclaimed Water Transmission** includes high service pumping and large-diameter piping used to transfer water from the WRF to the storage reservoir at water supply facilities.

Table F-8.
Force Main Improvement Summary

Force Main Diameter (in)	Length of Force Main Improvement (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
10	-	5,411	5,411
16	5,400	5,400	5,400
20	11,815	6,202	6,202
24	31,182	21,222	-
Total	**48,397**	**38,235**	**17,013**

- **Reclaimed Water Storage and Distribution** includes reclaimed water storage tanks at the WSFs, booster pumping at the WSFs, and distribution mains used to distribute the reclaimed water to the one square-mile grid.

Because the location of the WRFs changes in this evaluation, the amount and size of piping and pumping needed to convey water from the WRFs to the reclaimed water storage tanks at the WSFs differs. However, because the WSF locations and the reclaimed water demands are the same in all alternatives, the reclaimed water storage and distribution components do not change among the alternatives. The reclaimed water storage and booster pumping is co-located with the water supply facilities so that untreated groundwater can be used to supplement the reclaimed water distribution system in periods of high demand or in the event that development and reclaimed water demand exceed the available supply.

F.4.4.1. Reclaimed Water Transmission

The pumping requirements and transmission mains needed to convey reclaimed water from the WRFs to the reclaimed water storage facilities are summarized in Tables F-9 and F-10, respectively. Transmission pumping (Table F-9) includes pumping at the WRF as well as booster pumping needed at pressure zone boundaries to convey reclaimed water to the storage tanks at higher elevations. As shown in Table F-9, although the number of transmission pumping stations stays the same in each alternative, the total pumping capacity needed increases as the number of WRFs decreases. In Alternatives 2 and 3, because of the large elevation difference between the WRF location and the reclaimed storage locations, intermediate transmission booster pumping was needed to alleviate high pressures at the WRF. The intermediate pumping was not needed in Alternative 1 because the elevation differences are considerably smaller. As shown in Table F-10, transmission piping quantities and diameters increase as the number of WRFs decreases.

F.4.4.2. Reclaimed Water Storage and Distribution

As noted previously, because reclaimed water storage locations and demands do not change between the alternatives, the amount of storage (Table F-11), booster pumping

Table F-9.
Reclaimed Transmission Pumping Summary

Alternative	Location / Map ID	Type	Pressure Zone	Total Flow (gpm)	Head (ft)
Alternative 1 (6 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	5,750	245
	WRF 3	HSP	2	12,600	282
	WRF 4	HSP	4	7,600	467
	WRF 5	HSP	4	9,500	513
	WRF 6	HSP	8	6,700	415
Alternative 2 (4 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	5,750	245
	WRF 3	HSP	2	12,600	282
	WRF 7	HSP	4	23,961	350
	B4	TBP	7 to 8	3,560	222
	B5	TBP	5 to 6	13,576	90
Alternative 3 (3 WRFs)	WRF 1	HSP	1	7,274	218
	WRF 2	HSP	2	19,990	396
	B6	TBP	4 to 5	13,329	312
	B4	TBP	7 to 8	2,072	287
	WRF 3	HSP	2	22,270	311
	B7	TBP	3 to 4	5,188	343

Note: HSP= High Service Pumps at WRFs, TBP= Transmission Booster Pump

Table F-10.
Reclaimed Transmission Mains Summary

Reclaimed Transmission Main Diameter (in)	Length of Transmission Main (ft)		
	Alternative 1 (6 WRFs)	Alternative 2 (4 WRFs)	Alternative 3 (3 WRFs)
12	41,641	34,822	34,822
16	75,204	75,225	35,968
20	21,865	45,204	39,053
24	37,292	23,977	33,979
30	28,686	6,819	6,819
36	38,919	38,170	38,329
42	0	83,697	120,929

Table F-11.
Proposed Additional Reclaimed Water Storage

SPA	Location	Type.	Status	Capacity (MG)
SPA 1	WSF 4 (Rancho Gabriela)	Ground Tank	Future	1.75
	WSF 1 (Ashton Ranch)	Ground Tank	Future	2.76
SPA 2	WSF 5 (Desert Oasis)	Ground Tank	Future	0.75
SPA 3	WSF 38	Ground Tank	Future	2.00
	WSF 37	Ground Tank	Future	2.00
SPA 4	WSF 40	Ground Tank	Future	1.44
	WSF 42	Ground Tank	Future	0.76
	WSF 45	Ground Tank	Future	2.00
	WSF 44	Ground Tank	Future	1.42
SPA 5	WSF 39	Ground Tank	Future	4.00
	WSF 41	Ground Tank	Future	1.98
	WSF 43	Ground Tank	Future	1.47
SPA 6	WSF 46	Ground Tank	Future	1.86
	WSF 47	Ground Tank	Future	1.12
	B1*	Ground Tank	Future	3.16

Note: *Storage facility offsite than WSF, supplies PZ 10, 11, and 12

capacity (Table F-12), and distribution piping (Table F-13) is the same in all alternatives. The reclaimed storage tanks and booster pumps were located at the WSF locations identified in the drinking water infrastructure alternatives. The purpose of co-locating these facilities is so that untreated ground water can be used to supplement the reclaimed distribution system in the event that reclaimed water demand exceeds the supply or if the reclaimed water supply is interrupted for any reason. The purpose of the booster pumps is to provide sufficient pressure within the distribution mains such that the minimum pressure is achieved at the pressure zone boundaries. The distribution mains supply reclaimed water throughout service area. The layout of the new distribution mains was similar to the piping layout established in the most economical drinking water infrastructure alternative. The existing reclaimed distribution mains in portions of SPA 1 and SPA2 were also included in the model analysis.

Table F-12.
Proposed Additional Reclaimed Water Booster Pumping

Location	Pressure Zone	Total Flow (gpm)	Head (ft)
WSF 4 (Rancho Gabriela)	1	3,650	110
WSF 1 (Ashton Ranch)	1	5,400	75
WSF 5 (Desert Oasis)	2	3,300	60
WSF 5 (Desert Oasis)	3	3,250	185
WSF 37	3	4,200	166
WSF 38	3	3,900	128
WSF 40	4	3,000	130
WSF 42	5	1,600	125
WSF 44	6	3,000	135
WSF 45	7	4,000	150
WSF39	4	8,400	140
WSF 41	5	4,150	145
WSF 43	6	3,100	130
WSF 46	8	3,900	127
WSF 47	9	2,350	170
B1	9 to 10	6,000	200
B8	10 to 11	3,200	125
B9	11 to 12	1,500	130

Table F-13.
Proposed Additional Reclaimed Water Distribution Mains

Diameter (in)	Total Length (ft)
4	998
8	109,259
10	514
12	889,206
16	914,525
20	59,838
24	32,425
30	25,526
36	9,566

F.4.5. Recharge Facilities

All reclaimed water that is not reused is recharged using surface spreading basins. Recharge facilities (Table F-14) were designed and sized using the preliminary criteria described above. The land requirements in the table account for the wet/dry ratio, berms, ramps, and roads. The piping and pumping requirements to convey water to the recharge basins were included above with the reclaimed water transmission infrastructure. The total amount of water needing to be recharged is the same in all alternatives; however, the amount of recharge capacity needed in each location changes:

- In Alternative 1, reclaimed water is recharged in the SPA where it is generated.
- In Alternative 2, reclaimed water from SPAs 1, 2, and 3 is recharged in the SPA where it is generated. Two-thirds of the reclaimed water from the SPA 4/5/6 WRF will be recharged in SPA 4. The remaining one-third will be recharged in SPA 5, and no water will be recharged in SPA 6.
- In Alternative 3, reclaimed water from SPA 1 is recharge in SPA 1. One-third of the reclaimed water from the SPA 2/4/6 WRF will be recharged in SPA 2. The remaining two-thirds will be recharged in SPA 4. One third of the reclaimed water from the SPA 3/5 WRF will be recharged in SPA 3. The remaining two-thirds will be recharged in SPA 5. No water will be recharged in SPA 6.

F.5. Basis of Costs

Capital and O&M cost estimates were developed for the required system improvements and upgrades identified for each infrastructure alternative. The cost estimates presented herein are primarily based on capital improvement plan budgets, bid tabulations, and unit cost data from the cities of Surprise, Phoenix, Peoria, Avondale, and El Mirage. Existing studies, recent projects with similar components, manufacturer's budget estimates, standard construction cost estimating manuals, and engineering judgment were also used to refine the estimated if necessary. The level of accuracy for the cost estimates corresponds to the Class 4 estimate as defined by the Association for the Advancement of Cost Engineering (AACE) International. This level of engineering cost estimating is approximate and generally made without detailed engineering data and site layouts, but is appropriate for preliminary budget-level estimating. The accuracy range of a Class 4 estimate is minus 15 to plus 20 percent in the best case and minus 30 percent to plus 50 percent in the worst case.

The unit capital costs include materials of construction, installation, contractor costs (overhead, profit, bonding, mobilization), and engineering. For infrastructure calculated from equipment and concrete costs, a 30 percent level of planning contingency was added (i.e., WRF facilities). The unit O&M costs include labor, power, chemicals, maintenance, and materials. All costs are in October 2008 dollars referenced to an Engineering News Record Construction Cost Index (ENR CCI) of 8,623.

Table F-14.
Recharge Capacity and Land Requirements

Alternative	Recharge Location	Total Recharge Capacity (mgd)	Existing Recharge Capacity (mgd)	Additional Recharge Capacity Needed (mgd)	Additional Land Requirements (acres)
Alternative 1 (6 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	8.2	-	8.2	86
	SPA 3	18.2	-	18.2	182
	SPA 4	11.0	-	11.0	113
	SPA 5	13.9	-	13.9	141
	SPA 6	9.6	-	9.6	100
	Total	**83.5**	**6.9**	**76.6**	**780**
Alternative 2 (4 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	8.2	-	8.2	86
	SPA 3	18.2	-	18.2	182
	SPA 4	23.0	-	11.0	229
	SPA 5	11.5	-	13.9	118
	Total	**83.5**	**6.9**	**76.6**	**773**
Alternative 3 (3 WRFs)	SPA 1	22.6	6.9[1]	15.7	159
	SPA 2	9.6	-	9.6	99
	SPA 3	10.7	-	10.7	110
	SPA 4	19.2	-	19.2	192
	SPA 5	21.4	-	21.4	213
	Total	**83.5**	**6.9**	**76.6**	**774**

NOTE:
(1) Assumes 24 vadose zones (200 gpm each) are already planned or constructed and the existing SPA 1 WRF spreading basins are lined and used for reclaimed water storage.

The relative economic feasibility of the alternatives was compared based on an equivalent present worth cost basis. The equivalent present worth cost for each alternative is the sum of total capital costs, plus the estimated annual O&M cost, annualized over a 20-year study period at an interest rate of 7 percent.

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
CAPITAL COSTS					
Land	$40,000	$/acre	8090	$40,000	2008 land appraisal for SPA 5 WRF
Gravity Sewers					
8"	$104	$/LF	7751	$116	City of Phoenix 2006 Infrastructure
10"	$122	$/LF	7751	$136	Financing Plan (< 20 ft depth)
12"	$144	$/LF	7751	$160	
15"	$169	$/LF	7751	$188	
18"	$202	$/LF	7751	$225	
21"	$240	$/LF	7751	$267	
24"	$285	$/LF	7751	$317	
27"	$322	$/LF	7751	$358	
30"	$342	$/LF	7751	$380	
36"	$386	$/LF	7751	$429	
42"	$436	$/LF	7751	$485	
48"	$505	$/LF	7751	$562	
54"	$574	$/LF	7751	$639	
60"	$635	$/LF	7751	$706	
66"	$695	$/LF	7751	$774	
72"	$756	$/LF	7751	$841	
78"	$816	$/LF	7751	$908	
Lift Stations					
0 to < 2 mgd	$2,161,875	$/MGD	7751	$2,410,000	City of Phoenix 2006 Infrastructure
2 to < 4 mgd	$1,012,708	$/MGD	7751	$1,130,000	Financing Plan
4 to < 7 mgd	$792,250	$/MGD	7751	$880,000	
7 to < 10 mgd	$627,781	$/MGD	7751	$700,000	
10 to < 18 mgd	$510,344	$/MGD	7751	$570,000	
Force Mains					
4"	$104	$/LF	7751	$116	City of Phoenix 2006 Infrastructure
6"	$118	$/LF	7751	$131	Financing Plan
8"	$151	$/LF	7751	$168	
10"	$186	$/LF	7751	$207	
12"	$201	$/LF	7751	$224	
14"	$231	$/LF	7751	$257	
16"	$257	$/LF	7751	$286	
18"	$283	$/LF	7751	$315	
20"	$309	$/LF	7751	$344	
24"	$362	$/LF	7751	$402	
Water Reclamation Facilities					
0 to < 7 mgd	$9.65	$/gal	7888	$10.55	MBR Facility (WaterReuse Foundation
7 to < 13 mgd	$8.59	$/gal	7888	$9.39	Decision Support System)
13 to < 18 mgd	$7.45	$/gal	7888	$8.14	
18 to < 30 mgd	$6.78	$/gal	7888	$7.41	
Reclaimed Water Pipelines					
4"	$68	$/LF	8623	$68	$17/in-ft ≤ 18 inch-diameter, $20/in-ft >
6"	$102	$/LF	8623	$102	20 inch-diameter (rounded averages
8"	$136	$/LF	8623	$136	from recent City of Phoenix bid
10"	$170	$/LF	8623	$170	tabulations, City of Avondale 2008-
12"	$204	$/LF	8623	$204	2009 CIP, City of Peoria 2008-2009
14"	$238	$/LF	8623	$238	CIP and Bid Tabulations, and City of
16"	$272	$/LF	8623	$272	Surprise 2008-2009 CIP)
18"	$306	$/LF	8623	$306	
20"	$400	$/LF	8623	$400	
24"	$480	$/LF	8623	$480	
30"	$600	$/LF	8623	$600	
36"	$720	$/LF	8623	$720	
42"	$840	$/LF	8623	$840	

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
Recharge Basins					
Basins	$96,667	$/acre	8090	$100,000	Goodyear Adaman Design Concept Report
Monitoring Wells and Piezometers	$500,000	per location	8623	$500,000	Engineering Judgement
Reservoirs (covered)					
0.0 to < 2.5 MG	$1,366,850	$/MG	7751	$1,520,000	Adapted from City of Phoenix Water
2.5 to < 4.0 MG	$1,202,667	$/MG	7751	$1,340,000	System Master Plan and City of Peoria
4.0 to < 7.5 MG	$929,140	$/MG	7751	$1,030,000	2008-2009 CIP
Reclaimed Water Booster Pump Stations					
0 to < 7 mgd	$ 326,180	$/MGD	7751	$360,000	City of Phoenix 2006 Infrastructure
7 to < 13 mgd	$ 206,870	$/MGD	7751	$230,000	Financing Plan
13 to < 17 mgd	$ 171,900	$/MGD	7751	$190,000	
17 to < 25 mgd	$ 147,740	$/MGD	7751	$160,000	
25 to < 35 mgd	$ 115,520	$/MGD	7751	$130,000	
Pressure Reducing Valves					
3 to < 6 mgd	$ 350,600	$/MGD	7751	$390,000	City of Phoenix Water System Master

NOTES:

(1) October 2008 Costs (ENR CCI = 8,623).

(2) Unit capital costs include materials of construction, installation and contractor overhead and profit.

Summary of Operations and Maintenance Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Oct. 2008)	SOURCE
O&M COSTS					
Gravity Sewers	$3,200	$/mile/year	7355	$3,800	Peoria Water Reuse Master Plan
Lift Stations					
Power	$0.08	$/kWh	8623	$0.08	Engineering Judgment
Maintenance	3% of capital			3% of capital	Engineering Judgment
Water Reclamation Facilities					
0 to < 7 mgd	0.43	$/1,000 gal	7888	$0.47	WateReuse Foundation WRF Decision Support System
7 to < 13 mgd	0.29	$/1,000 gal	7888	$0.32	
13 to < 18 mgd	0.24	$/1,000 gal	7888	$0.26	
18 to < 30 mgd	0.2	$/1,000 gal	7888	$0.22	
Pipelines	$3,200	$/mile/year	7355	$3,800	Peoria Water Reuse Master Plan
Recharge Basin	$0.05	$/1,000 gal	7355	$0.06	Peoria Water Reuse Master Plan
CAGRD Recharge	$281.00	$/AF	8623	$281.00	CAGRD 2008/09 Published Rate
Reservoir	$6,400.00	$/yr-each	7355	$7,500.00	Peoria Water Reuse Master Plan
Booster Pump Station					
Power	$0.08	$/kWh	8623	$0.08	Engineering Judgment
Maintenance	3% of capital			3% of capital	Engineering Judgment
Pressure Reducing Valves	1% of capital			1% of capital	Engineering Judgment

NOTES:

(1) October 2008 Costs (ENR CCI = 8,623).

Present Worth Assumptions	
Discount Rate	**7%**
Term	**20**

Alternative 1: Six WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1365	acres	$ 40,000	$ 54,600,000
Gravity Sewers				
8"	106784	LF	$ 116	$ 12,354,927
10"	161321	LF	$ 136	$ 21,895,324
12"	106862	LF	$ 160	$ 17,119,317
15"	224452	LF	$ 188	$ 42,199,843
18"	142289	LF	$ 225	$ 31,975,942
21"	111991	LF	$ 267	$ 29,901,640
24"	73777	LF	$ 317	$ 23,391,954
27"	37030	LF	$ 358	$ 13,265,091
30"	73260	LF	$ 380	$ 27,873,639
36"	68478	LF	$ 429	$ 29,406,208
42"	15433	LF	$ 485	$ 7,485,788
48"	21045	LF	$ 562	$ 11,823,361
54"	15430	LF	$ 639	$ 9,859,389
60"	0	LF	$ 706	$ -
66"	0	LF	$ 774	$ -
72"	0	LF	$ 841	$ -
78"	0	LF	$ 908	$ -
Lift Stations				
0 to < 2 mgd	0	MGD	$ 2,410,000	$ -
2 to < 4 mgd	0	MGD	$ 1,130,000	$ -
4 to < 7 mgd	10.5	MGD	$ 880,000	$ 9,240,000
7 to < 10 mgd	15.9	MGD	$ 700,000	$ 11,130,000
10 to < 18 mgd	11	MGD	$ 570,000	$ 6,270,000
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	0	LF	$ 207	$ -
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	11815	LF	$ 344	$ 4,064,189
24"	31182	LF	$ 402	$ 12,543,913
Water Reclamation Facilities				
0 to < 7 mgd	68,000,000	gallon	$ 11	$ 717,344,397
7 to < 13 mgd	0	gallon	$ 9	$ -
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	930,847	LF	$ 204	$ 189,892,864
14"	0	LF	$ 238	$ -
16"	989,729	LF	$ 272	$ 269,206,280
18"	0	LF	$ 306	$ -
20"	81,703	LF	$ 400	$ 32,681,200
24"	69,716	LF	$ 480	$ 33,463,852
30"	54,212	LF	$ 600	$ 32,527,344
36"	48,485	LF	$ 720	$ 34,908,948
42"	0	LF	$ 840	$ -
Recharge Basins				
Basins	898	acres	$ 100,000	$ 89,800,000
Monitoring Wells and Piezometers	6	locations	$ 500,000	$ 3,000,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 1: Six WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	93	MGD	$ 360,000	$ 33,480,000
7 to < 13 mgd	57	MGD	$ 230,000	$ 13,110,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	0	MGD	$ 160,000	$ -
25 to < 35 mgd	0	MGD	$ 130,000	$ -
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,894,363,242
O&M COSTS				
Gravity Sewers	219	miles	$ 3,800	$ 833,518
Lift Stations				
Power	2545163	kwh	$ 0.08	$ 203,613
Maintenance	1	3% of capital	$ 799,200	$ 799,200
Water Reclamation Facilities				
0 to < 7 mgd	24,820,000	1,000 gallons	$ 0.47	$ 11,667,068
7 to < 13 mgd	0	1,000 gallons	$ 0.32	$ -
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7,646,248	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	433	miles	$ 3,800	$ 1,644,841
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	38,761,125	kwh	$ 0.08	$ 3,100,890
Maintenance	1	3% of Capital	$ 1,471,800	$ 1,471,800
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 24,050,921
PRESENT WORTH OF O&M[2]				$ 254,795,799
TOTAL PRESENT WORTH[2]				$ 2,149,159,040

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

Alternative 2: Four WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1178	acres	$ 40,000	$ 47,120,000
Gravity Sewers				
8"	96364	LF	$ 116	$ 11,149,331
10"	122254	LF	$ 136	$ 16,592,948
12"	107436	LF	$ 160	$ 17,211,272
15"	193555	LF	$ 188	$ 36,390,812
18"	144664	LF	$ 225	$ 32,509,665
21"	127698	LF	$ 267	$ 34,095,415
24"	90346	LF	$ 317	$ 28,645,370
27"	72469	LF	$ 358	$ 25,960,245
30"	81591	LF	$ 380	$ 31,043,381
36"	57620	LF	$ 429	$ 24,743,504
42"	15433	LF	$ 485	$ 7,485,788
48"	8822	LF	$ 562	$ 4,956,317
54"	21689	LF	$ 639	$ 13,858,736
60"	0	LF	$ 706	$ -
66"	14500	LF	$ 774	$ 11,216,768
72"	0	LF	$ 841	$ -
78"	7528	LF	$ 908	$ 6,836,667
Lift Stations				
0 to < 2 mgd	1.9	MGD	$ 2,410,000	$ 4,579,000
2 to < 4 mgd	0	MGD	$ 1,130,000	$ -
4 to < 7 mgd	10.5	MGD	$ 880,000	$ 9,240,000
7 to < 10 mgd	8.7	MGD	$ 700,000	$ 6,090,000
10 to < 18 mgd	0	MGD	$ 570,000	$ -
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	5411	LF	$ 207	$ 1,119,673
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	6202	LF	$ 344	$ 2,133,398
24"	21222	LF	$ 402	$ 8,537,199
Water Reclamation Facilities				
0 to < 7 mgd	20,000,000	gallon	$ 11	$ 210,983,646
7 to < 13 mgd	48,000,000	gallon	$ 9	$ 450,739,777
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	924,029	LF	$ 204	$ 188,501,827
14"	0	LF	$ 238	$ -
16"	989,750	LF	$ 272	$ 269,212,033
18"	0	LF	$ 306	$ -
20"	105,042	LF	$ 400	$ 42,016,900
24"	56,401	LF	$ 480	$ 27,072,672
30"	32,345	LF	$ 600	$ 19,406,970
36"	47,736	LF	$ 720	$ 34,370,129
42"	83,697	LF	$ 840	$ 70,305,589
Recharge Basins				
Basins	890	acres	$ 100,000	$ 89,000,000
Monitoring Wells and Piezometers	5	locations	$ 500,000	$ 2,500,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 2: Four WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	74	MGD	$ 360,000	$ 26,640,000
7 to < 13 mgd	57	MGD	$ 230,000	$ 13,110,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	20	MGD	$ 160,000	$ 3,200,000
25 to < 35 mgd	35	MGD	$ 130,000	$ 4,550,000
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,901,672,862
O&M COSTS				
Gravity Sewers	220	miles	$ 3,800	$ 836,266
Lift Stations				
Power	1,679,906	kwh	$ 0.08	$ 134,392
Maintenance	1	3% of capital	$ 597,270	$ 597,270
Water Reclamation Facilities				
0 to < 7 mgd	7,300,000	1,000 gallons	$ 0.47	$ 3,431,490
7 to < 13 mgd	17,520,000	1,000 gallons	$ 0.32	$ 5,554,226
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7,646,248	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	445	miles	$ 3,800	$ 1,691,124
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	42,816,543	kwh	$ 0.08	$ 3,425,323
Maintenance	1	3% of Capital	$ 1,499,100	$ 1,499,100
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 21,499,182
PRESENT WORTH OF O&M[2]				$ 227,762,645
TOTAL PRESENT WORTH[2]				$ 2,129,435,508

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

Alternative 3: Three WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
CAPITAL COSTS				
Land	1089	acres	$ 40,000	$ 43,560,000
Gravity Sewers				
8"	96381	LF	$ 116	$ 11,151,298
10"	117923	LF	$ 136	$ 16,005,122
12"	88705	LF	$ 160	$ 14,210,562
15"	213484	LF	$ 188	$ 40,137,719
18"	149936	LF	$ 225	$ 33,694,416
21"	133334	LF	$ 267	$ 35,600,230
24"	83578	LF	$ 317	$ 26,499,488
27"	73202	LF	$ 358	$ 26,222,824
30"	62162	LF	$ 380	$ 23,651,121
36"	39736	LF	$ 429	$ 17,063,657
42"	13826	LF	$ 485	$ 6,706,311
48"	27226	LF	$ 562	$ 15,295,929
54"	54279	LF	$ 639	$ 34,682,941
60"	16021	LF	$ 706	$ 11,315,196
66"	0	LF	$ 774	$ -
72"	4430	LF	$ 841	$ 3,725,044
78"	0	LF	$ 908	$ -
Lift Stations				
0 to < 2 mgd	1.9	MGD	$ 2,410,000	$ 4,579,000
2 to < 4 mgd	4.2	MGD	$ 1,130,000	$ 4,746,000
4 to < 7 mgd	6.3	MGD	$ 880,000	$ 5,544,000
7 to < 10 mgd	0	MGD	$ 700,000	$ -
10 to < 18 mgd	0	MGD	$ 570,000	$ -
Force Mains				
4"	0	LF	$ 116	$ -
6"	0	LF	$ 131	$ -
8"	0	LF	$ 168	$ -
10"	5411	LF	$ 207	$ 1,119,673
12"	0	LF	$ 224	$ -
14"	0	LF	$ 257	$ -
16"	5400	LF	$ 286	$ 1,542,728
18"	0	LF	$ 315	$ -
20"	6202	LF	$ 344	$ 2,133,398
24"	0	LF	$ 402	$ -
Water Reclamation Facilities				
0 to < 7 mgd	4000000	gallon	$ 11	$ 42,196,729
7 to < 13 mgd	64000000	gallon	$ 9	$ 600,986,369
13 to < 18 mgd	0	gallon	$ 8	$ -
18 to < 30 mgd	0	gallon	$ 7	$ -
Reclaimed Water Pipelines				
4"	998	LF	$ 68	$ 67,864
6"	0	LF	$ 102	$ -
8"	109,259	LF	$ 136	$ 14,859,259
10"	514	LF	$ 170	$ 87,380
12"	924,029	LF	$ 204	$ 188,501,827
14"	0	LF	$ 238	$ -
16"	950,493	LF	$ 272	$ 258,534,096
18"	0	LF	$ 306	$ -
20"	98,891	LF	$ 400	$ 39,556,380
24"	66,404	LF	$ 480	$ 31,874,006
30"	32,345	LF	$ 600	$ 19,406,970
36"	47,895	LF	$ 720	$ 34,484,184
42"	120,929	LF	$ 840	$ 101,580,360
Recharge Basins				
Basins	891	acres	$ 100,000	$ 89,100,000
Monitoring Wells and Piezometers	5	locations	$ 500,000	$ 2,500,000
Reservoirs (covered)				
0.0 to < 2.5 MG	21.31	MG	$ 1,520,000	$ 32,391,200
2.5 to < 4.0 MG	3.16	MG	$ 1,340,000	$ 4,234,400
4.0 to < 7.5 MG	4	MG	$ 1,030,000	$ 4,120,000

Alternative 3: Three WRFs

ITEM	QUANTITY	UNITS	UNIT COST	COST[1]
Reclaimed Booster Pump Stations				
0 to < 7 mgd	78	MGD	$ 360,000	$ 28,080,000
7 to < 13 mgd	31	MGD	$ 230,000	$ 7,130,000
13 to < 17 mgd	13	MGD	$ 190,000	$ 2,470,000
17 to < 25 mgd	19	MGD	$ 160,000	$ 3,040,000
25 to < 35 mgd	61	MGD	$ 130,000	$ 7,930,000
Pressure Reducing Valves				
3 to < 6 mgd	22.5	MGD	$ 390,000	$ 8,775,000
TOTAL CAPITAL COST				$ 1,901,092,682
O&M COSTS				
Gravity Sewers	222	miles	$ 3,800	$ 845,085
Lift Stations				
Power	819,169	kwh	$ 0.08	$ 65,534
Maintenance	1	3% of capital	$ 446,070	$ 446,070
Water Reclamation Facilities				
0 to < 7 mgd	1460000	1,000 gallons	$ 0.47	$ 686,298
7 to < 13 mgd	23360000	1,000 gallons	$ 0.32	$ 7,405,635
13 to < 18 mgd	0	1,000 gallons	$ 0.26	$ -
18 to < 30 mgd	7646247	1,000 gallons	$ 0.22	$ 1,671,744
Pipelines	445	miles	$ 3,800	$ 1,692,552
Recharge Basin	29,091,303	1,000 gallons	$ 0.06	$ 1,705,332
CAGRD Recharge	2,679	AF	$ 281.00	$ 752,664
Reservoirs	15	each	$ 7,500.00	$ 112,500
Reclaimed Booster Pump Stations				
Power	50,152,393	kwh	$ 0.08	$ 4,012,191
Maintenance	1	3% of Capital	$ 1,459,500	$ 1,459,500
Pressure Reducing Valves	1	1% of Capital	$ 87,750.00	$ 87,750
TOTAL O&M COST				$ 20,942,855
PRESENT WORTH OF O&M[2]				$ 221,868,908
TOTAL PRESENT WORTH[2]				$ 2,122,961,590

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.

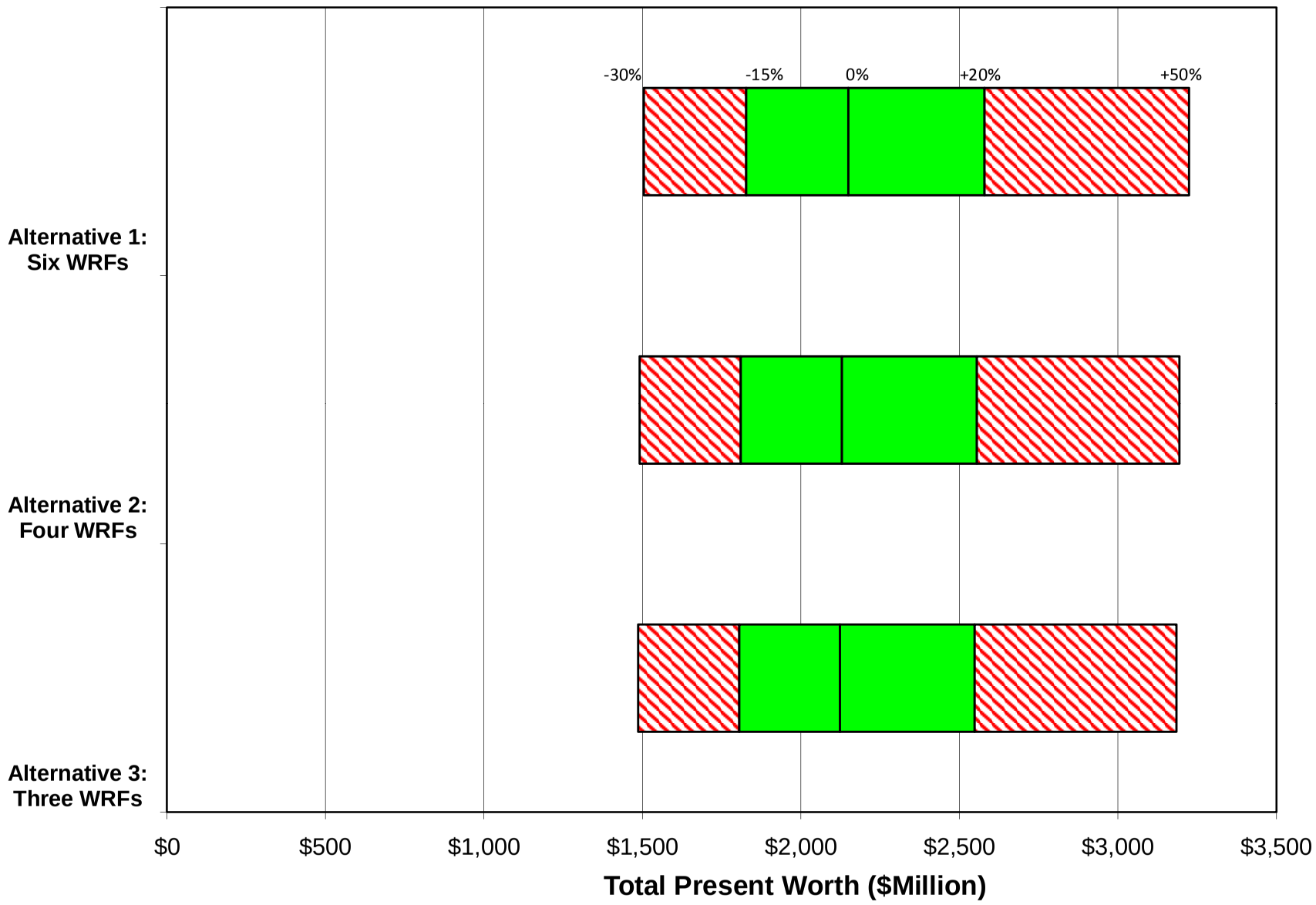
Comparison Cost Summary of Wastewater and Reclaimed Water Alternatives

	Present Value ($)		
	Alternative 1: Six WRFs	**Alternative 2: Four WRFs**	**Alternative 3: Three WRFs**
Capital			
Land	$54,600,000	$47,120,000	$43,560,000
Gravity Sewers	$278,552,423	$302,696,219	$315,961,858
Lift Stations	$26,640,000	$19,909,000	$14,869,000
Force Mains	$18,150,830	$13,332,998	$4,795,799
Water Reclamation Facilities	$717,344,397	$661,723,423	$643,183,098
Reclaimed Water Pipelines	$607,694,992	$665,900,623	$688,952,327
Recharge Basins	$92,800,000	$91,500,000	$91,600,000
Reservoirs (covered)	$40,745,600	$40,745,600	$40,745,600
Reservoirs (uncovered)	$0	$0	$0
Booster Pump Stations	$49,060,000	$49,970,000	$48,650,000
Pressure Reducing Valves	$8,775,000	$8,775,000	$8,775,000
TOTAL CAPITAL COST ($)	**$1,894,363,242**	**$1,901,672,862**	**$1,901,092,682**
Operation and Maintenance			
Gravity Sewers	$833,518	$836,266	$845,085
Lift Stations			
Power	$203,613	$134,392	$65,534
Maintenance	$799,200	$597,270	$446,070
Water Reclamation Facility	$13,338,812	$10,657,461	$9,763,678
Pipelines	$1,644,841	$1,691,124	$1,692,552
Recharge Basins	$1,705,332	$1,705,332	$1,705,332
CAGRD Replenishment	$752,664	$752,664	$752,664
Reservoirs	$112,500	$112,500	$112,500
Booster Pump Stations			
Power	$3,100,890	$3,425,323	$4,012,191
Maintenance	$1,471,800	$1,499,100	$1,459,500
Pressure Reducing Valves	$87,750	$87,750	$87,750
ANNUAL O&M COST ($)	**$24,050,921**	**$21,499,182**	**$20,942,855**
PRESENT WORTH O&M COST($)	**$254,795,799**	**$227,762,645**	**$221,868,908**
TOTAL PRESENT WORTH COST ($)	**$2,149,160,000**	**$2,129,436,000**	**$2,122,962,000**

NOTES:

[1] October 2008 Costs (ENR CCI = 8623).

[2] 20 Years, 7 Percent Interest.


-30%
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Alternative 1: Six WRFs
Alternative 2: Four WRFs
Alternative 3: Three WRFs
$0
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$2,500
$3,000
$3,500
Total Present Worth ($Million)

G. Unit Costs for Recommended Infrastructure Master Plans

Summary of Capital Unit Costs[1]

ITEM	COST	UNITS	CCI	COST (Jan. 2009)	SOURCE
DRINKING WATER CAPITAL COSTS					
Land	$40,000	$/acre	8090	$42,270	2008 land appraisal for SPA 5 WRF
Pipelines, in					
6	$102	$/LF	8623	$ 101	$17/in-ft ≤ 18 inch-diameter, $20/in-ft > 20 inch-diameter (rounded averages from recent City of Phoenix bid tabulations, City of Avondale 2008-2009 CIP, City of Peoria 2008-2009 CIP and Bid Tabulations, and City of Surprise 2008-2009 CIP)
8	$136	$/LF	8623	$ 135	
10	$170	$/LF	8623	$ 169	
12	$204	$/LF	8623	$ 202	
14	$238	$/LF	8623	$ 236	
16	$272	$/LF	8623	$ 270	
18	$280	$/LF	8623	$ 278	
20	$395	$/LF	8623	$ 392	
24	$420	$/LF	8623	$ 416	
30	$520	$/LF	8623	$ 516	
36	$610	$/LF	8623	$ 605	
42	$700	$/LF	8623	$ 694	
48	$790	$/LF	8623	$ 783	
54	$880	$/LF	8623	$ 872	
60	$970	$/LF	8623	$ 962	
Reservoirs (covered), MG					
0 to < 2.5	$1,366,850	$/MG	7751	$ 1,507,584	City of Phoenix 2006 Infrastructure Financing Plan and City of Peoria 2008-2009 CIP
2.5 to < 4.0	$1,202,667	$/MG	7751	$ 1,326,496	
4 to < 7.5	$929,140	$/MG	7751	$ 1,024,806	
7.5 to < 12.5	$813,040	$/MG	7751	$ 896,752	
12.5 to < 17.5	$766,413	$/MG	7751	$ 845,325	
17.5 to < 25	$745,145	$/MG	7751	$ 821,867	
25 to < 35	$720,277	$/MG	7751	$ 794,438	
35 to < 40	$727,263	$/MG	7751	$ 802,143	
Booster Pump Stations					
0 to < 7 mgd	$ 326,180	$/MGD	7751	$ 359,764	City of Phoenix 2006 Infrastructure Financing Plan
7 to < 13 mgd	$ 206,870	$/MGD	7751	$ 228,170	
13 to < 17 mgd	$ 171,900	$/MGD	7751	$ 189,599	
17 to < 25 mgd	$ 147,740	$/MGD	7751	$ 162,952	
25 to < 35 mgd	$ 115,520	$/MGD	7751	$ 127,414	
35 to < 50 mgd	$ 100,935	$/MGD	7751	$ 111,327	
50 to < 60 mgd	$ 84,597	$/MGD	7751	$ 93,307	
Pressure Reducing Valves					
3 to < 6 mgd	$ 350,600	$/MGD	7751	$ 386,699	City of Phoenix Water System Master Plan
6 to < 15 mgd	$ 139,290	$/MGD	7751	$ 153,632	
15 to < 20 mgd	$ 82,400	$/MGD	7751	$ 90,884	
20 to < 50 mgd	$ 44,580	$/MGD	7751	$ 49,170	
50 to < 60 mgd	$ 33,167	$/MGD	7751	$ 36,582	
Production Well	$2,200,000	$/well	8623	$ 2,181,136	City of Surprise CIP (1,500 gpm); comparable to City of
Arsenic Treatment	$1,225,000	$/MGD	8090	$ 1,294,512	Evaluation of Lease or Purchase of Skid-mounted Arsenic
Water Treatment Plant (~15 mgd)	$2,830,000	$/MGD	7888	$ 3,067,170	City of Avondale Surface Water Treatment and Opportunities (2007)
RECLAIMED WATER AND WASTEWATER CAPITAL COSTS					
Gravity Sewers, in					
8	$104	$/LF	7751	$ 115	City of Phoenix 2006 Infrastructure Financing Plan (< 20 ft depth)
10	$122	$/LF	7751	$ 135	
12	$144	$/LF	7751	$ 159	
15	$169	$/LF	7751	$ 186	
18	$202	$/LF	7751	$ 223	
21	$240	$/LF	7751	$ 265	
24	$260	$/LF	7751	$ 287	
27	$285	$/LF	7751	$ 314	
30	$310	$/LF	7751	$ 342	
36	$360	$/LF	7751	$ 397	
42	$410	$/LF	7751	$ 452	
48	$460	$/LF	7751	$ 507	
54	$525	$/LF	7751	$ 579	
60	$590	$/LF	7751	$ 651	
66	$655	$/LF	7751	$ 722	
72	$720	$/LF	7751	$ 794	
78	$785	$/LF	7751	$ 866	

ITEM		COST	UNITS	CCI	COST (Jan. 2009)	SOURCE
Lift Stations, mgd						
0	**to < 2**	$2,161,875	$/MGD	7751	$ 2,384,466	City of Phoenix 2006 Infrastructure Financing Plan
2	**to < 4**	$1,012,708	$/MGD	7751	$ 1,116,979	
4	**to < 7**	$792,250	$/MGD	7751	$ 873,822	
7	**to < 10**	$627,781	$/MGD	7751	$ 692,419	
10	**to < 18**	$510,344	$/MGD	7751	$ 562,890	
18	**to < 32**	$375,530	$/MGD	7751	$ 414,195	
32	**to < 40**	$285,788	$/MGD	7751	$ 315,213	
Force Mains, in						
4		$104	$/LF	7751	$ 115	City of Phoenix 2006 Infrastructure Financing Plan
6		$118	$/LF	7751	$ 130	
8		$151	$/LF	7751	$ 167	
10		$186	$/LF	7751	$ 205	
12		$201	$/LF	7751	$ 222	
14		$231	$/LF	7751	$ 254	
16		$257	$/LF	7751	$ 283	
18		$283	$/LF	7751	$ 312	
20		$309	$/LF	7751	$ 341	
24		$362	$/LF	7751	$ 399	
30		$440	$/LF	7751	$ 486	
Water Reclamation Facilities, mgd						
0	**to < 7**	$9.65	$/gal	7888	$ 10.46	MBR Facility (WaterReuse Foundation Decision Support System)
7	**to < 13**	$8.59	$/gal	7888	$ 9.31	
13	**to < 18**	$7.45	$/gal	7888	$ 8.07	
18	**to < 30**	$6.78	$/gal	7888	$ 7.35	
30	**to < 60**	$5.88	$/gal	7888	$ 6.37	
60	**to < 80**	$5.01	$/gal	7888	$ 5.43	
Reclaimed Water Transmission and Distribution Mains, in						
4		$68	$/LF	8623	$ 67	$17/in-ft ≤ 18 inch-diameter, $20/in-ft > 20 inch-diameter (rounded averages from recent City of Phoenix bid tabulations, City of Avondale 2008-2009 CIP, City of Peoria 2008-2009 CIP and Bid Tabulations, and City of Surprise 2008-2009 CIP)
6		$102	$/LF	8623	$ 101	
8		$136	$/LF	8623	$ 135	
10		$170	$/LF	8623	$ 169	
12		$204	$/LF	8623	$ 202	
14		$238	$/LF	8623	$ 236	
16		$272	$/LF	8623	$ 270	
18		$280	$/LF	8623	$ 278	
20		$395	$/LF	8623	$ 392	
24		$420	$/LF	8623	$ 416	
30		$520	$/LF	8623	$ 516	
36		$610	$/LF	8623	$ 605	
42		$700	$/LF	8623	$ 694	
48		$790	$/LF	8623	$ 783	
54		$880	$/LF	8623	$ 872	
60		$970	$/LF	8623	$ 962	
Recharge Basins						
Basins		$96,667	$/acre	8090	$ 102,152	Goodyear Adaman Design Concept Report
Monitoring Wells and Piezometers		$500,000	per location	8623	$ 495,713	Engineering Judgement
Reservoirs (covered), MG						
0	**to < 2.5**	$1,366,850	$/MG	7751	$ 1,507,584	Adapted from City of Phoenix Water System Master Plan and City of Peoria 2008-2009 CIP
2.5	**to < 4.0**	$1,202,667	$/MG	7751	$ 1,326,496	
4	**to < 7.5**	$929,140	$/MG	7751	$ 1,024,806	
7.5	**to < 12.5**	$813,040	$/MG	7751	$ 896,752	
12.5	**to < 17.5**	$766,413	$/MG	7751	$ 845,325	
17.5	**to < 25**	$745,145	$/MG	7751	$ 821,867	
25	**to < 35**	$720,277	$/MG	7751	$ 794,438	
35	**to < 40**	$727,263	$/MG	7751	$ 802,143	
Reclaimed Water Booster Pump Stations, mgd						
0	**to < 7**	$ 326,180	$/MGD	7751	$ 359,764	City of Phoenix 2006 Infrastructure Financing Plan
7	**to < 13**	$ 206,870	$/MGD	7751	$ 228,170	
13	**to < 17**	$ 171,900	$/MGD	7751	$ 189,599	
17	**to < 25**	$ 147,740	$/MGD	7751	$ 162,952	
25	**to < 35**	$ 115,520	$/MGD	7751	$ 127,414	
35	**to < 50**	$ 100,935	$/MGD	7751	$ 111,327	
50	**to < 60**	$ 84,597	$/MGD	7751	$ 93,307	
Pressure Reducing Valves, mgd						
1	**to < 3 mgd**	$ 491,473	$/MGD	7751	$ 542,077	City of Phoenix Water System Master Plan
3	**to < 6**	$ 350,600	$/MGD	7751	$ 386,699	
6	**to < 15**	$ 139,290	$/MGD	7751	$ 153,632	
15	**to < 20**	$ 82,400	$/MGD	7751	$ 90,884	
20	**to < 50**	$ 44,580	$/MGD	7751	$ 49,170	
50	**to < 60**	$ 33,167	$/MGD	7751	$ 36,582	

NOTES:

(1) January 2009 Costs (ENR CCI = 8,549).

(2) Unit capital costs include engineering/design, materials of construction, installation and contractor overhead and profit.

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